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# Problematizing Socio-Scientific Issues: An Approach to Understanding Student Decision-Making Using Construal Level Theory

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PROBLEMATIZING SOCIO-SCIENTIFIC ISSUES: AN APPROACH TO  
UNDERSTANDING STUDENT DECISION-MAKING USING CONSTRUAL LEVEL  
THEORY

by

Ashley McKenzie Peterson

A THESIS

Presented to the Faculty of  
The Graduate College at the University of Nebraska  
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For the Degree of Master of Science

Major: Natural Resource Sciences

Under the Supervision of Professors Cory T. Forbes and Jenny M. Dauer

Lincoln, Nebraska

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Ashley McKenzie Peterson, M.S.

University of Nebraska, 2017

Advisers: Cory T. Forbes and Jenny M. Dauer

Socio-scientific issues (SSIs) are challenges at the intersection of science and everyday life that require use of scientific knowledge, argumentation skills, personal values, and morals to articulate science-informed decisions. While addressing SSIs, the ways in which individuals define a problem will influence the solution or decision reached. The problem definition can differ along many dimensions, including content and construal level. A construal is a mental construction of the past and future, other places and people, and unlikely events. Construal Level Theory (CLT) suggests pro-environmental intentions are associated with abstract situations. I explore the application of CLT to teaching and learning about science-informed decision-making through two instructional units: an undergraduate biodiversity SSI ( $n = 73$ ) and a 6<sup>th</sup> grade wind energy SSI ( $n = 116$ ). Data collected included student artifacts and, for the undergraduate study, a survey on value orientations. Research questions explore how students problematize each SSI topically and along a continuum from concrete to abstract and how their problematization is related to the decision-making processes and their ultimate decision. In the undergraduate population, students' abstract and concrete

problematizations was related to values they chose to use as criteria in their decision-making processes, however it did not predict their decisions. In the 6<sup>th</sup> grade population, abstract and concrete problematizations and perceptions of the wind turbine were associated, but there was no association with their decisions.

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## **Chapter I: Scientific Literacy and Decision-Making**

Science is the result of careful observation, which, through inductive reasoning, leads to an understanding of the natural world around oneself. According to DeBoer (1991), formal education originally revolved around classical studies such as reading, writing, arithmetic, and a study of the classical languages. The introduction of science as a school subject meant students could investigate and draw their own inferences about the world around them rather than rely upon memorization. Unlike classical studies, science required higher levels of thinking to make sense of observations and gain an understanding of broader concepts in the natural world. Although many educators and the general public did not respect science at the onset of its introduction to the educational system, the utility of science would be the basis for discussions on things such as sanitation, the human body, child rearing, and other potentially life-improving bases of knowledge that reading, writing, arithmetic, and classical languages could not provide (DeBoer, 1991).

Today's science still provides life-improving bases of knowledge for society. However, the only way this can happen is if people take the initiative to apply science knowledge to situations and decisions in their daily lives. This ability to understand and apply science knowledge to daily life is called "scientific literacy" (Roberts, Bybee, Lederman, & Abell, 2014). At its essence, this means a person is able to transfer (or utilize) science knowledge in many contexts, including novel contexts in which they never received formal education. Scientifically literate individuals can engage in decision-making and question others' conclusions based on several lines of scientific

information without reliance on the interpretation from others. To some, scientific literacy may seem unnecessary, but scientific literacy means individuals can incorporate science, evidence-based considerations with their societal, value-based considerations (such as beliefs).

Socio-scientific issues (SSIs) are one valuable context through which instructors can encourage the development of scientific literacy. SSIs require the use of scientific knowledge, personal values, and morals at personal or societal levels to engage in decision-making (Kolstø et al., 2006; Sadler, 2004). As Bardwell (1991) points out, the initial definition or problematization of an issue will influence people's ultimate. Balgopal, Wallace, and Dahlberg (2016) demonstrated that students with different demographics will define issues differently and additional research widely supports that the differences in the presentation or definition of issues can influence behavioral intentions and decisions (Gifford & Comeau, 2011; Halverson, Siegel, & Freyermuth, 2009; Morton, Rabinovich, Marshall, & Bretschneider, 2011).

One difference in problem definitions is in construal. A construal is a mental construction of the past and future, other places, other people, and unlikely events (Trope & Liberman, 2010). Without construal, people can only experience what is happening here and now without the ability to remember the past, predict the future, speculate what might have been, or imagine the reactions of other people. A high construal reflects a very abstract understanding of a person, place, thing, or situation where only the most important/defining characteristics of the person, place, thing, or situation are preserved. Highly construed situations/people/places are put into general categories that aid in

remembering, predicting, and speculating based on an understanding of the general category. Construal Level Theory (CLT) states that psychological distance (sometimes thought of as personal relevance) is higher at higher levels of abstraction (Trope & Liberman, 2010).

Construal Level Theory is based in four dimensions: theoretical, social, spatial, and temporal. Low abstractions are categorized as anything that happens to oneself, is happening in the present time and location, and is usual. Low-level construal is associated with specific, observable details. A high abstraction, in contrast, are characterized as anything that happens to someone unlike oneself, happening at a future or past time, at a location far away, and is very unusual. A high-level construal is a big-picture understanding of situations where only the essential details of the situation are considered. High levels of abstraction are associated with high psychological distance and low levels of abstraction are associated with low psychological distance. This theory, in practice, has implications for personal relevance to individuals depending on how abstract the situation, place, or person is to an individual and has implications for how students address issues based on their mental construction.

The body of research on CLT is one potential method to better understand conceptions of situations and their implications for decision-making. I explore the relationship between undergraduate students' problem construal and decisions on a prairie dog issue and on sixth grade students' problem construal, perceptions, and decisions on a wind energy issue.

For the undergraduate study, I selected prairie dogs given its relevance to

individuals living in the Great Plains region near the location of the school. The prairie dog issue requires a multifaceted understanding about ecosystems, economics, natural resources, and social impacts. Broadly, this issue reflects a concern expressed by scientists (Costanza et al., 2014; Edwards & Abivardi, 1998; Gowdy, 1997) regarding the underestimation of the value of ecosystems and biodiversity to human well-being in an economics-driven world. Furthermore, this issue requires reconciliation between environmental integrity and agricultural production, an issue that Robertson and Swinton (2005) argue is one of the grandest challenges for agriculture in recent years. Prairie dog educational units have been studied in the past (Fox-Parrish & Jurin, 2008), but to the best of my knowledge, there are no instructional units that approach prairie dogs as a social and scientific issue. Value Belief Norm (VBN) theory predicts that pre-disposition toward pro-environmental behavior stems from human-nature values (i.e., altruistic, biospheric, egoistic) (Stern, 2000). Construal Level Theory (CLT) suggests pro-environmental intentions are associated with abstract situations (Haden, Niles, Lubell, Perlman, & Jackson, 2012), but also that behavioral intentions are better aligned with personal values in abstract situations (Eyal, Sagristano, Trope, Liberman, & Chaiken, 2009). The design of the unit allows for exploration of problem conceptualization and decision-making using CLT, but also explore the role of personal values in their decision-making processes. Additionally, CLT suggests that some abstract situations can illicit better alignment between intended action and personal values (Eyal et al., 2009).

To explore problematization of an SSI by elementary/middle school students, I utilized a curriculum co-created by researchers and the middle school teachers. The

curriculum was designed around a real-world, local scenario involving the proposed construction of a wind farm. This issue was selected given its proximity to the community in which the students resided, which was presumed to make the situation more relevant to the students. The topic itself is a multifaceted renewable energy issue, which requires an understanding about renewable energy, resource management, social impacts and public attitudes, economics, and environmental impacts. Prior research indicates that students perform poorly on knowledge tests about energy (Bodzin, 2012; DeWaters & Powers, 2011), prompting a desire to create an educational unit on energy and, more specifically, wind energy. Previous research in CLT suggests individuals will be able to generate more pros and fewer cons about actions when a situation is distant (abstract) (Eyal, Liberman, Trope, & Walther, 2004) and that, in abstract situations, proposed actions have a more pro-environmental focus than adaptive (Haden et al. 2012). This prior research provides suggests that students with high (abstract) construal of the wind farm issue should be more focused on positive aspects of the wind farm and pro-environmental action and, presumably, would be more inclined to build the wind farm. In contrast, those with low (concrete) construal of the situation should be more focused on feasibility issues, which may leave the students more inclined to decide against building the wind farm.

## **Chapter II: Construal and Value-Belief Norm Theories: Implications for Undergraduate Decision-Making on a Prairie Dog Socio-Scientific Issue**

### **Abstract**

The objective of science education is to develop scientific literacy for decision-making in daily life. Socio-scientific issues (SSI) and decision-making frameworks can help students attain these objectives. This research uses Value Belief Norm (VBN) theory and Construal Level Theory (CLT) to explore students' use of personal values in their decision-making processes and the relationship between abstract and concrete problematization and their decision-making. Using mixed methods, I conclude that abstraction has implications for values used in the decision-making process on a prairie dog agricultural production and ecosystem and preservation issue, but that neither abstraction nor value orientations had a significant influence on students' final decisions.

### **2.1 Introduction**

The objective of science education varies widely, but De Boer (2000) suggests that ultimately the objective is to have “a public that finds science interesting and important, who can apply science to their own lives, and who can take part in the conversations regarding science that take[s] place in society.” National Research Council (2009) and many education researchers (Aikenhead, 2006; Kolstø et al., 2006; Sadler, 2004) resoundingly desire to equip students with the skills needed to engage in socially responsible, science-informed decision-making on issues in society. One proposed tool to meet these objectives are socio-scientific issues (SSIs), which require the use of scientific

knowledge to formulate opinions and engage in decision-making using science knowledge, personal values, and morals at personal or societal levels (Kolstø et al., 2006; Sadler, 2004). Contemporary SSIs include animal testing for medical purposes, climate change, “fat taxes” on “unhealthy” foods, and more.

One critical SSI is the need to find balance between agricultural production and preservation of biodiversity or natural ecosystems. Worldwide, ecosystems provide a finite amount of provisioning services (food, water, raw materials), regulating services (air quality regulation, climate regulation, waste treatment), habitat services (nursery services, genepool protection), and cultural services (aesthetics, recreation, cognitive development) (Millennium Ecosystem Assessment, 2005). As human population continues to grow, sustainability issues arise and cause concern for human well-being. One potential reaction to this environmental issue is to promote environmental literacy through a SSI that requires the use of ecological knowledge, socio-political knowledge, environmental issue knowledge, cognitive skills, and environmentally responsible behaviors that are encompassed by national environmental literacy standards (NAAEE 2000/2004).

### **2.1.1 Prairie dogs as a Socio-Scientific Issue**

Prairie dog (*Cynomys ludovicianus*) presence in Midwestern states is a SSI that requires a multifaceted understanding about the Great Plains ecosystem, agriculture (especially ranching operations), economics, and the social and political climate surrounding prairie dogs. Broadly, this issue reflects a concern expressed by scientists (Costanza et al., 2014; Edwards & Abivardi, 1998; Gowdy, 1997) regarding the



underestimation of the value of ecosystems and biodiversity to human well-being in an economics-driven world. This issue requires reconciliation between environmental integrity and agricultural production, an issue that Robertson and Swinton (2005) argue is one of the greatest challenges for agriculture in recent years. According to De Groot et al. (2012), the Great Plains ecosystem, a grassland, has a value of \$2,871/ha/year in provisioning services, regulating services, habitat services, and cultural services. Prairie dogs are natural fauna of the Great Plains upon which many other species utilize for food or shelter, potentially classifying them a “keystone” species (Miller et al., 2000; Stapp, 1998) and should be carefully considered for management to preserve the Great Plains ecosystem. However, prairie dogs are small, colonial herbivores that “clip” grass and dig holes, which raises concerns for ranchers and researchers about reduced profits from decreased cattle weight gain (Derner, Detling, & Antolin, 2006; O'meilia, Knopf, & Lewis, 1982).

The social and political climate surrounding this issue evolved over a hundred years (Jones, 1999) and interplays with changing values on wildlife seen in other studies (Manfredo, Teel, & Bright, 2003). The issue affects many stakeholders directly including ranchers, farmers, environmentalists, public land and wildlife managers, residents of some rural and urban areas, and more (Lamb, Reading, & Andelt, 2006). Largely, research suggests that ranchers and individuals living near colonies view prairie dogs as pests and favor controlling their populations (Reading & Kellert, 1993; Zinn & Andelt, 1999) even though the cost of control may be higher in some situations than losses incurred from reduced cattle weight gain (Collins, Workman, & Uresk, 1984). A more

recent study by Sexton, Brinson, Ponds, and Cline (2001) revealed that nearly 40% of study participants thought economic growth and protection of the environment should be balanced, which raises questions about current prairie dog control practices that tend to favor agricultural production. The tradeoffs between environmental integrity and agricultural production create a compelling contemporary SSI, which still requires reconciliation today within the Great Plains.

### **2.1.2 Objectives**

I explore the relationship between students' human-nature value orientations (thought to contribute to predispositions for pro-environmental behavior), the students' degree of abstraction in their problematization of the prairie dog issue, and their decisions. In this study, I analyze only three steps in student work within a structured decision-making framework: their problem definition (step 1), criteria (step 3), and choice (step 6).

This research will contribute to the body of knowledge about decision-making regarding environmental issues, which could have implications for university level teaching practices. Additionally, understanding the driving factors of pro-environmental decisions could lead to broader implications for teaching practices at all ages.

A first goal for this paper is to describe student decision-making on the prairie dogs SSI. Few studies in science education have documented student thinking or decision-making on prairie dog educational units. Fox-Parrish and Jurin (2008) described ninth grade student outcomes from a prairie dog field-based educational unit as apathy toward the species (i.e., little to no concern for prairie dogs or their well-being),

egocentric or utilitarian views of prairie dogs (i.e. prairie dogs should provide personal or societal benefits), and naïve conceptions as to the purpose of prairie dogs (i.e., little to no understanding about prairie dogs and their role in the prairie ecosystem). Initial framing of issues is important because it can influence intended behavior (Gifford & Comeau, 2011; Halverson et al., 2009; Morton et al., 2011), which means it is imperative to have a foundation of knowledge regarding student thinking on the prairie dog issue. Therefore, my first multipart research question is: how do students problematize the issue (topically and in terms of abstraction), what value themes do they include in their decision-making process and what decisions do they come to?

The second goal of this paper is to explore how students' values and abstraction (how distant they portray the issue from themselves), both theorized to predict behavior, relates to the students' decision about prairie dogs. Value Belief Norm (VBN) theory predicts that pre-disposition toward pro-environmental behavior stems from human-nature values (i.e., altruistic, biospheric, and egoistic) (Stern, 2000). Additionally, Construal Level Theory (CLT) suggests pro-environmental intentions are associated with abstract situations (Haden et al., 2012), but also that behavioral intentions are better aligned with personal values in abstract situations (Eyal et al., 2009). In a classroom setting, I elicited students' decision-making processes using a structured decision-making framework that asked the students to be explicit about the problem they were addressing, potential options to address the problem, their criteria (or desired outcomes of a management option), their analysis of tradeoffs in the issue, and their chosen solution to their stated problem. Each of these steps in the decision-making process may reflect

students' behavioral intentions or potential decision-making about the SSI. Therefore, my second research question is: how do abstraction in problem framing and values relate to student decision-making processes such as framing the problem and stating criteria for evaluating the solution, and their ultimate decisions on the prairie dog issue?

A third goal of this paper is to explore potential connections between VBN theory and CLT. If connections exist, it is important to illuminate them for an improved understanding of both theories. I hypothesize that egoistic values are associated with low levels of abstraction since both are characterized by higher focus on one's self (Lieberman & Trope, 2008; Stern, 2000). I also hypothesize that biospheric and altruistic value orientations will be associated with abstract conceptions since both are characterized by focus on others. Therefore, my third research question is: how does abstraction in problem framing relate to value orientations (i.e., egoistic, altruistic, and biospheric value orientations)?

### **2.1.3 Influence of Problematization, Construal Level Theory, and Value Belief Norm Theory on Decision-Making**

Several researchers (Arvai, Campbell, Baird, & Rivers, 2004; Edelson, Tarnoff, Schwille, Bruozas, & Switzer, 2006; Hammond, Keeney, & Raiffa, 1999; Ratcliffe, 1997) suggest aiding students in decision-making by providing a decision-making framework. Some frameworks, such as those by Arvai et al. (2004) and Hammond et al. (1999) include identification of the problem as a first step, which is both appropriate and necessary. As Bardwell (1991) points out, the initial definition or problematization of issues will influence the person's ultimate decision. Balgopal, Wallace, and Dahlberg

(2016) demonstrated that students with different demographics define issues differently from each other and additional research widely supports that differences in the presentation or definition of issues can influence behavioral intentions and decisions (Gifford & Comeau, 2011; Halverson et al., 2009; Morton et al., 2011).

CLT states that psychological distance and personal relevance are related to how abstract or concrete an individuals' mental construction. People, places, things, and actions are construed abstractly when referring to the future, a distant place, or someone who is very dissimilar. In this situation, psychological distance is high. A concrete construal presents itself as something happening to oneself in the present and in a local area. In concrete constructions, psychological distance is low. Research on CLT often explores the influence of abstract and concrete thinking on behavioral intentions that result from psychological distance (Liberman & Trope, 2008; Trope & Liberman, 2010). Research by Haden et al. (2012) suggests that under concrete (local) scenarios, agricultural farmers were more interested in safeguarding their own self-interest (through adaption to climate change) than when they were presented with a global scenario, which elicited more cooperative environmental behavior intentions (e.g. mitigation practices).

In addition to the influence of abstraction on behavioral intentions, researchers know students utilize personal values when addressing SSIs (Halverson et al., 2009; Sadler, 2004). VBN theory suggests human-nature value orientations translate into beliefs about the world, which lead to the formation of personal norms (or a sense of obligation to act) in environmental matters, and eventually results in associated pro-environmental behaviors (Stern, 2000). This theory is thought to account for some predisposition toward

pro-environmental behavior and, presumably, pro-environmental intentions throughout decision-making. Additional work by Eyal et al. (2009) on the interaction between abstraction and values suggests there is better alignment between values and behavioral intentions in abstract (future) conditions than in concrete (present, feasibility-constrained) conditions.

The research questions for this study are:

RQ1: How do students problematize the issue (topically and in terms of abstraction), what value themes do they include in their problem statement and criteria, and what decisions do they arrive at?

RQ2: How do abstraction in problem framing and values relate to student decision-making processes such as framing the problem and stating criteria for evaluating the solution, and their ultimate decisions on the prairie dog issue?

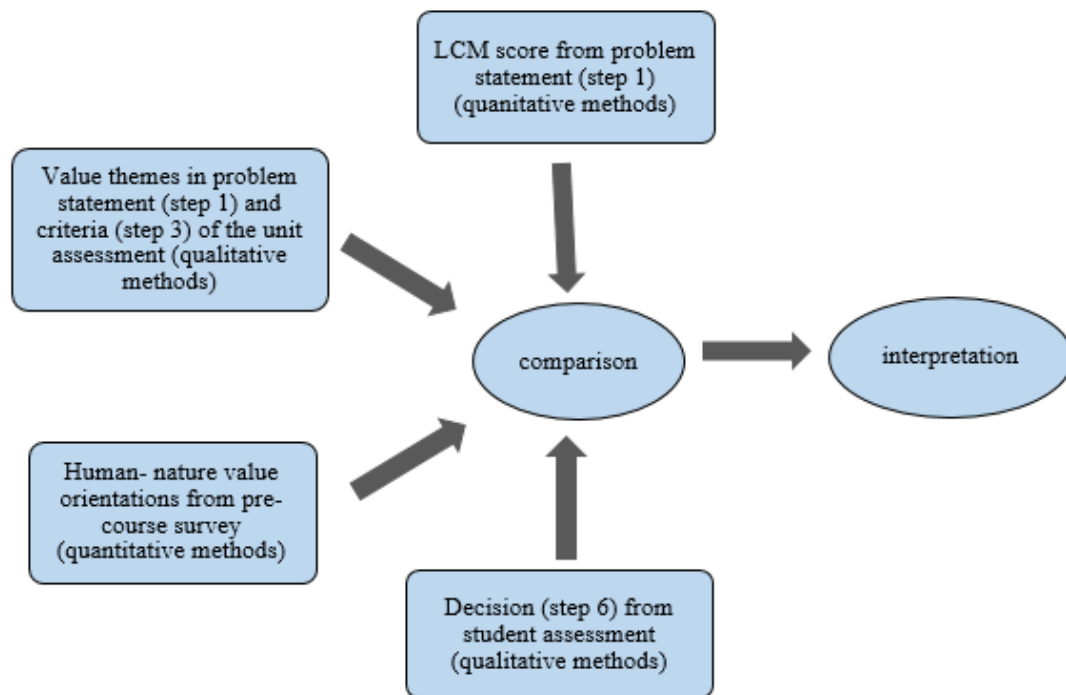
RQ3: How does abstraction in problem framing relate to value orientations (i.e., egoistic, altruistic, and biospheric value orientations)?

## **2.2 Methods**

### **2.2.1 Design**

This study follows the convergent parallel mixed method design as described by Creswell and Plano Clark (2011a) (Figure 2.1). The approach to this research is a pragmatic worldview (Creswell & Plano Clark, 2011a), which allows for the use of both qualitative and quantitative research methods to explore and find solutions to problems. Researchers commonly use this approach for mixed methods research since there is emphasis on using the methods, techniques, and procedures that best aid researchers in

accomplishing their research (Creswell & Plano Clark, 2011a). I selected the convergent parallel mixed method design given the importance of the Likert human-nature value orientations, Linguistic Category Model (LCM) scores, and themes in students' problematization of the issue and their use of values themes throughout their work. I cannot address the research questions in full with solely qualitative or quantitative methods.



*Figure 2.1.* Research design using qualitative and quantitative methods.

**2.2.1a Classroom Context.** This study based on student work in an introductory course, “Science and Decision-making for a Complex World,” which is a required course at a large Midwestern university for all students enrolled in the College of Agriculture and Natural Resources. Each year, about five lecture classes are taught,

containing 120 students each. The lectures meet twice weekly for seventy-five minutes for ten weeks. These weeks included a two-week introductory unit and four two-week units focused on water, food, biofuel, and biodiversity socio-scientific issues. The introductory unit included information on “fast and slow thinking” (Covitt, Harris, & Anderson, 2013; Kahneman, 2011) and cognitive biases and heuristics (Arvai, Campbell, Baird, & Rivers, 2004) that support the need for a formal decision-making framework. During the last five weeks of class, the students worked on a group final project on an SSI of their own interest and did not attend lecture. The students were required to attend an associated weekly recitation with about thirty other students for fifty minutes for fifteen weeks.

Lectures were designed for active learning, including small group discussions, clicker questions, and worksheets to facilitate the decision-making process and content understanding. The graduate student assistants engaged students in discussion during lecture and lead discussion during recitation, similar to that described by Otero, Pollock, McCray, & Finkelstein (2006). The graduate students also evaluated the students’ work throughout the semester. Students submitted three assignments for grading in each unit: an assessment targeted at the evaluation of popular media articles and scientific journal articles for their trustworthiness (Appendix A), a quiz on factual information from the unit (Appendix B), and a structured decision-making unit assessment (Appendix C).

**2.2.1b Participants.** During spring 2016 when this study was conducted, 73 students consented to the use of their coursework for research purposes and completed all required course materials utilized in this research study. The students completed an



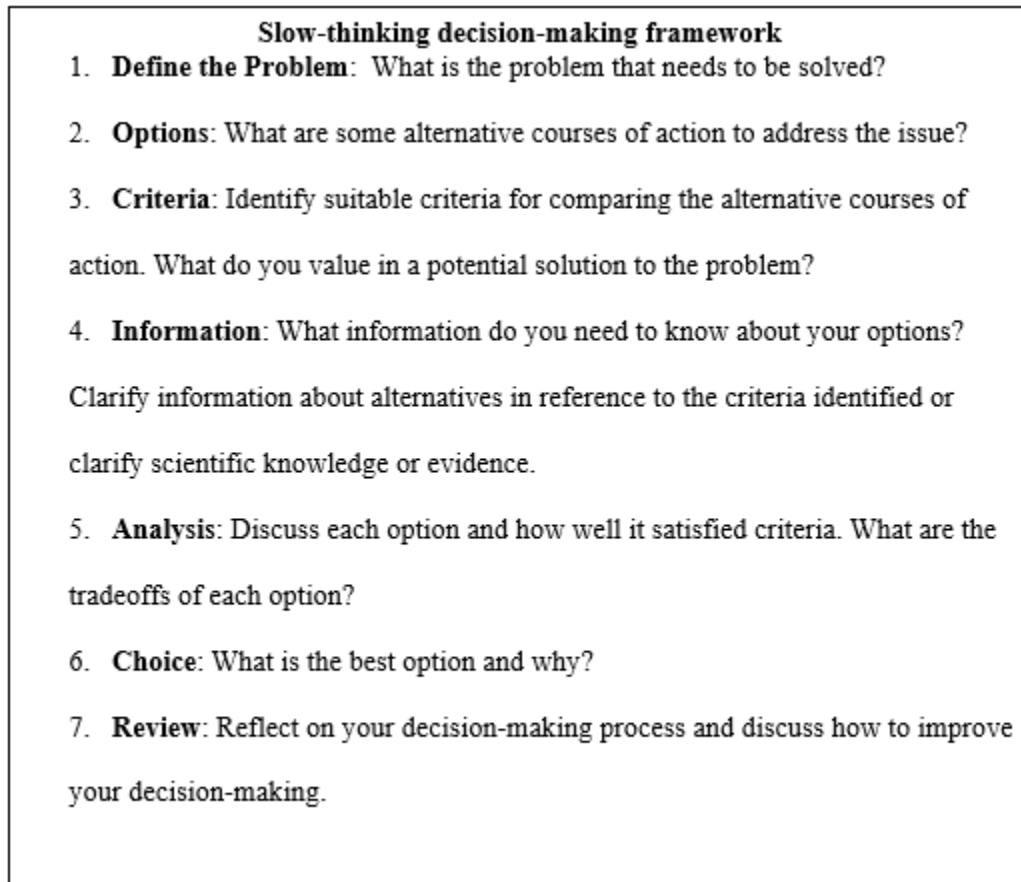
online pre-course survey via Qualtrics, which included the consent form, questions about basic demographics, and a human-nature value orientations survey based on VBN theory. This pre-course survey revealed that about 60% of the class was male and about 40% was female. More than half the students (63%) were incoming freshman, about a quarter were sophomores (22%), and the remaining students were upperclassmen (15%). Almost three fourths of the students (72%) were STEM majors (Agronomy, Fisheries and Wildlife, and Forensic Science were top majors) and one fourth were non-STEM majors (Professional Golf Management and Hospitality were top majors) with a small portion of students who were undecided (3%). Few students identified themselves as coming from urban backgrounds (15%) compared to rural (44%) and suburban (40%) areas. The majority of the students were in-state students or from a nearby Midwestern state, and there were four international students. As a population, the students reported the prairie dog issue had low personal relevance to them ( $M = 4.34$ ,  $SD = 2.31$ ) on a scale of 1 (not at all important) to 10 (one of the most important issues).

### **2.2.2 Data Sources and Collection**

**2.2.2a Value Orientation Survey.** Students answered Likert-scale questions in a pre-course survey to assess their human-nature value orientations based on VBN Theory (Stern, 2000). This survey (J. I. De Groot & Steg, 2008) consists of 12 items which measure an individual's beliefs about human--nature relationships (i.e., altruistic, biospheric, egoistic) on an 8-point scale (-1 = "opposed to my values," 1 = "not important" to 7 = "extremely important") for guiding principles in their lives such as "free of war and conflict" (altruistic), "harmony with other species" (biospheric), and

“material possessions, money” (egoistic). According to J. I. De Groot and Steg (2007), the environmental value orientation survey is a valid and reliable instrument that can be used for distinguishing between three distinct environmental value orientations and behavior-specific beliefs (i.e., awareness of environmental consequences and personal norms). The egoistic value orientation is negatively related to environmental behavior-specific beliefs whereas the biospheric value orientation is positively related (J. I. De Groot & Steg, 2007). Altruistic value orientations are weakly positive or not related to environmental behavior-specific beliefs (J. I. De Groot & Steg, 2007).

**2.2.2b Unit Assessments.** I collected students’ definition of the prairie dog problem (step 1), their criteria (step 3), and their choice (step 6) from a structured decision-making framework adapted from work by Grace and Ratcliffe (2002), Lee and Grace (2010), and Ratcliffe (1997) as a unit assessment. The unit assessment contained the seven steps displayed in Figure 2.2. Students provided three courses of action (step 2, options) to address the issue (step 1, problem definition) and two criteria (or desirable outcomes, step 3) by which they would assess their options (step 2, options). The students then assessed the tradeoffs of their options (step 5, analysis) with respect to their chosen criteria (step 3) and options (step 2). Students submitted their structured decision-making assessment electronically through their course management system for individual grades using a rubric based on quality of work in terms of analysis of tradeoffs, clarity of argument, and comprehensive reasoning. In this study, I analyzed three steps of the decision-making framework: their problem definition (step 1), criteria (step 3), and choice (step 6).



*Figure 2.2.* Formal structured decision-making framework.

### 2.2.3 Data Analyses and Organization

**2.2.3a Value Orientation Survey.** For each survey item, values could range from -1 to 7 with 7 indicating a high agreement with the value being a guiding force in their life and -1 indicating a lack of that value being a guiding force in their life. I averaged the four Likert responses for each human-nature value orientation to obtain the three value orientation scores (i.e. altruistic, biospheric, and egoistic) as prescribed by J. I. De Groot and Steg (2008).

I created a new variable, herein referred to as the “bio-ego score,” which was the

difference between each students' biospheric value orientation score and their egoistic value orientation score. As J. I. De Groot and Steg (2008) noted, individuals with high biospheric value orientation scores had the highest levels of environmentally significant intentions and associated behaviors whereas individuals with high egoistic value orientation scores had the lowest. The difference between these two scores should maximize the ability to see trends within environmentally significant behavior and intention within student decisions (Dauer, Lute, & Straka, 2017).

**2.2.3b Unit Assessments.** To assess abstraction of the students' problem statements, I used the LCM manual developed by Coenen, Hedeboew, and Semin (2006). The LCM manual describes a coding process to assess the use of concrete and abstract language for the creation of an "LCM score" of 1 (concrete) to 4 (abstract) that I used to assess level of abstraction in student problem statements (step 1 of the decision-making framework). The LCM contains coding instructions for adjectives (abstract), nouns (abstract), and verbs (ranging from low abstraction to moderate/high abstraction). I obtained the problem statement LCM score (herein referred to as "LCM score") by averaging the values assigned to each part of the students' problem statements using the LCM protocol. I assessed inter-rater reliability (IRR) between two coders as recommended by the LCM manual.

Two coders coded 10% of the problem statements on student unit assessments independently based on initial interpretation of how the rules in the LCM manual should be applied to student problem statements (step 1). IRR was very poor ( $k < 0.50$ ) during this first coding session. After this first coding session, discussion took place to

determine how unique, but common, statements about ongoing actions within their problem statements were to be handled within the data set. New rules clarified that in instances where an action was followed by conditions, the conditions were coded as a single adjective that described the action. Additionally, the term “declining” was considered an adjective because it was an unchanging feature about prairie dog populations. After clarification of coding rules, a new 10% subset of student problem statements were coded, which yielded an IRR ( $\kappa = 0.571$ ) that is considered a sufficient level of agreement above chance (Lombard, Snyder-Duch, & Bracken, 2002). After coding, the coders discussed discrepancies and were able to agree to 100%.

Value themes were developed using the value orientation survey by J. I. De Groot and Steg (2008) to analyze values used in the problem statement (step 1) and criteria (step 3). The egoistic value theme (E), for instance, was present if there was mention of money or material possessions since the original survey item asked if “material possessions, money” were guiding principles in their life. Likewise, this same method was used with biospheric (B) and altruistic (A) value themes with biospheric values focusing around “fitting into nature,” or “harmony with other species” and altruistic values focusing around being “free of war and conflict,” and having “equal opportunity for all”. Student responses were coded with multiple value themes when appropriate. A 10% sample of problem statements (step 1) and criteria (step 2) were coded individually by two coders. IRR between coders was high for the biospheric ( $\kappa = 0.452$ ,  $p = 0.030$ ) and egoistic ( $\kappa = 0.732$ ,  $p = 0.000$ ) themes and lower for the egoistic theme ( $\kappa = 0.452$ ,  $p = 0.030$ ). IRR was high for uncodeable responses as well ( $\kappa = 0.617$ ,  $p = 0.003$ ). After

discussion, the two coders were able to agree to 100%.

For this study, all statistical analyses, including the multinomial logistic regression models, one-way ANOVAs (and post-hoc analysis when appropriate), and kappa scores were analyzed using Statistical Package for the Social Sciences (SPSS).

**2.2.3c Limitations.** One limitation of this research is the ability to accurately measure how abstractly or concretely students have conceptualized the issue. There are several options for determining how abstract or concrete a portion of text is (e.g. Coenen et al., 2006 and Flesch, 1950) and each has its limitations. Given the wide array of problem statement types and language used by the students, the LCM tool used for this study often could not address some of the more unique statements made by the students, such as statements about ongoing actions. In these situations, the coders had to agree upon a rule, which the coders could consistently apply across all student problem statements. Initial attempts at coding without rules that were specific to my context resulted in very low IRR, but the clarified rules brought IRR between .5 and .6, which was better, though not as high as desired. Regardless of these issues, the LCM was necessary and helpful because it reduced the potential to inadvertently determine level of abstraction based on length or level of detail in students' problem statements.

## **2.3 Results**

### **2.3.1 Characterization of Unit Assessment**

To address my first research question, I explored the students' problem statements (step 1 of the unit assessment) in terms of problematization type, topic, and abstraction (the LCM score). I also explored the value themes present in the problem statements (step

1 of the unit assessment) and criteria (step 3) and the decision themes (step 6).

Four themes emerged in students' problematization types in response to the prompt, "Define the Problem: What is the problem that needs to be solved?" from step 1 from student unit assessment: situational description, course of action, question of action, and criteria (Table 2.1). Some problem statements were coded with multiple themes when appropriate. Some students included criteria (or outcomes) they desired. Situational description and course of action (53% and 52%, respectively) were the most common themes in problematization type. Only 16% of students mentioned both a course of action and provided a situational description. The variety of problem types suggests that it is either unclear to students how they should define a problem or that they have differing conceptualizations about what it means to define a problem.

*Table 2.1.* Characteristics of student problematization grouped by theme.

<u>Characteristic</u>	<u>Description</u>	<u>%</u>	<u>Example</u>
Situational description	A description of the situation without a specific course of action proposed.	53	Prairie dogs are becoming a problem in Nebraska, with two sides battling it out over what to do about them. One side wants them gone, they see them as a pest, the other side wants to protect them, and not let anyone harm them. There is no doubt that the prairie dogs are hurting ranchers by harming their land and making holes their cattle or horses step in and break legs, but prairie dogs are also part of a large ecosystem and play a key role for a lot of different animals. So the problem is what do we do about the prairie dog predicament? (s_60)
Course of action	A specific course of action (protecting, controlling,	52	How can we assure the protection of prairie dogs? (s_7)

	educating, etc.) is proposed.		
Question of action	There is a question about whether a specific course of action is best or should be done.	10	Should we conserve prairie dogs (s_47)
Includes criteria	Criteria by which to assess the outcomes of a course of action are included.	18	How do we protect prairie dogs so the black-footed ferret can be reintroduced and doesn't become further endangered. (s_1)

Several themes emerged in the problem statement topics (step 1 of the unit assessment), including the role of prairie dogs in the ecosystem (27%), the damages they can cause (26%), and action to control prairie dogs (25%) or conserve prairie dogs (23%) (Table 2.2). Of these top four themes, I noticed a general mirroring of percentages with students mentioning the positive and negative aspects of prairie dogs in almost equal amounts and the desire to control or conserve them in almost equal amounts. The topical differences in student problematization demonstrates that students choose to highlight different portions of the problem and that these differences can conflict with each other. It also gives indication that students are split about evenly between looking at negative influences of prairie dogs and the need to control them versus the environmental role of prairie dogs and the need to conserve them.

*Table 2.2. Themes in student problematization of the prairie dog issue.*

<u>Theme</u>	<u>%</u>	<u>Example</u>
Prairie dog role in ecosystem	27	...prairie dogs are also part of a large ecosystem and play a key role for a lot of different animals (s_60)



Damage from prairie dogs	26	There is no doubt that the prairie dogs are hurting ranchers by harming their land and making holes their cattle or horses step in and break legs (s_60)
Controlling prairie dogs	25	What methods should ranchers be allowed to use to get rid of prairie dogs damaging their property (s_73)
Conserving prairie dogs	23	The prairie dog population needs to be conserved (s_74)
Differing views	14	The problem is that some people do not like prairie dogs while others do (s_12)
Diminishing population concern	14	The issue at hand is that the current population of prairie dogs are decreasing (s_10)
Prairie dogs are pests	12	[prairie dogs] are being a major pest to farmers (s_23)
Pleasing groups	10	How should we manage prairie dogs in a way that could appease landowners as well as keep prairie dog populations at sustainable levels... (s_06)

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*Note.* Brackets are added by author for clarification.

I calculated the problem statement (step 1) LCM scores for the unit assessment to understand how abstract or concrete the prairie dog problem was to students. As a population ( $n = 73$ ), LCM scores for the problem statements (step 1 of the unit assessment) problematized the issue in a slightly more abstract manner ( $M = 2.96$ ,  $SD = 0.58$ ) (Figure 2.3). The lowest LCM score was 2.00 and the highest was 4.00, meaning there were no very concrete problematizations, but there were very abstract problematizations. The median was 3.00 and the mode was 3.33. Students with low LCM scores (concrete problematization) mentioned observable happenings such as, “The problem with prairie dogs is that they affect farmers and they want to get rid of them (s\_15).” Students with high LCM scores (abstract problematization) utilized interpretive

words while problematizing the issue such as, “the significant decline of the prairie dog population, throughout the US plains, has caused caused [*sic*] major disturbance in the ecosystem. (s\_72).” In the example a high LCM score, the student is discussing observable events such as the decline of the prairie dog population and disturbance in the ecosystem, but the quantifiers of “significant” and “major” are both interpretative words to describe the perceived extent of disturbance. This demonstrates that students’ problematization of the issue does, in fact, vary in psychological distance (or personal relevance) to the students. Some students define the problem concretely, others describe it abstractly, but many describe it using a combination of concrete and abstract ideas.

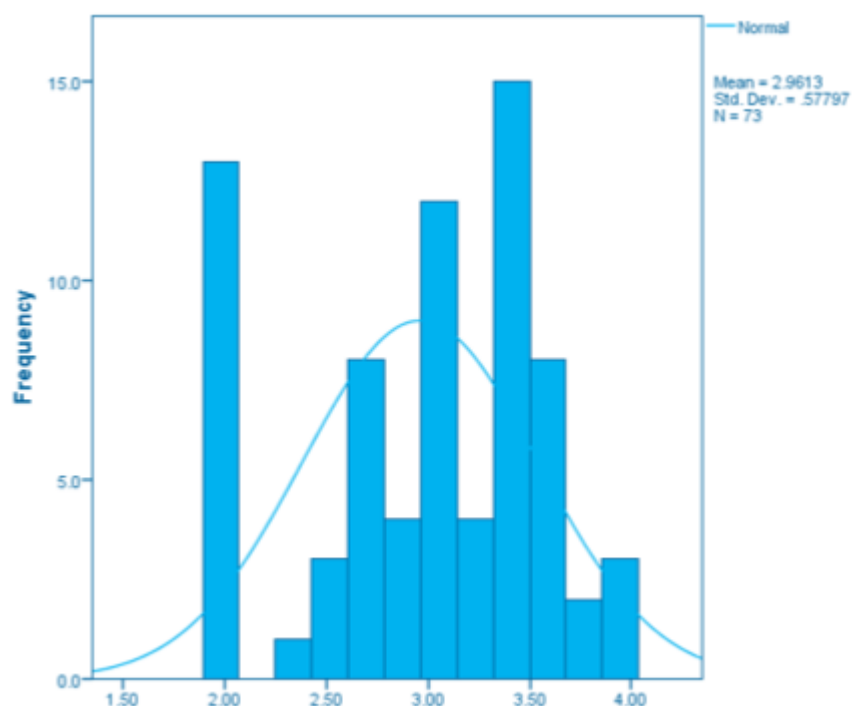


Figure 2.3. Student problem statement LCM scores.

To characterize student problem statements (step 1) and criteria (step 3) in their

unit assessments, I developed themes using the value orientation survey prompts (J. I. De Groot & Steg, 2008) for use on student problem statements (step 1) and criteria (step 3). About half of the student problem statements were directed toward a single value theme (56%) and half were directed at multiple value themes (44%) (Table 2.3). Problem statements were mostly directed toward the biospheric value theme (B) (67%) with egoistic value themes (E) used slightly less (59%) and altruistic value themes (A) being the least commonly used (33%).

*Table 2.3.* Altruistic (A), biospheric (B), and egoistic (E) value themes in student problem statements.

<u>Value Theme</u>	<u>%</u>	<u>Example</u>
B	26	What is the best way to preserve prairie dogs in Nebraska? (s_3)
E	21	The prairie dogs are a big problem for ranchers and farmland owners. They cause a lot of physical damage to crops and cattle (s_16)
BE	21	Prairie dogs are viewed as a pest to farmers and landowners yet provide great value to the ecosystem by helping out many other species. (s_79)
ABE	15	The problem that we are trying to solve is the controversy of prairie dogs in the state of Nebraska. The controversy is between the ranchers who want to eradicate the species, and the conservationists who want to conserve the prairie dog population. This is occurring because the ranchers bear the cost of prairie dogs through the value of their land, but the conservationists advocate for the animal because of the numerous benefits they contribute to the environment. I believe the problem to solve is how to best promote the conservation of prairie dogs while appeasing the ranchers concerns. (s_30)

Almost half (45%) of all students identified one or more criteria (step 3 of the unit

assessment) oriented toward the biospheric theme and egoistic theme (Table 2.4). The next most common combination of value themes in their criteria were all three value themes (18%). The least common combination of value themes used within the criteria was the altruistic value theme, occurring in only 3% of student assessments.

*Table 2.4.* Altruistic (A), biospheric (B), and egoistic (E) themes in student criteria.

<u>Value Theme</u>	<u>%</u>	<u>Example</u>
BE	45	Reduce the amount of land that prairie dogs take up while not getting rid of all the prairie dogs. Not to hurt/kill any of the prairie dogs. (s_27)
ABE	18	Maintain good public opinion of the controllers (farms/ranchers etc.). Minimize the environmental effect of controlling prairie dogs. Cost effectiveness of the control method. (s_11)
E	12	Would this negatively effect landowners economically? Would this take a significant amount of money to implement? (s_1)
AE	8	Money efficient. Make everyone happy (s_15)
AB	4	The best one is to make conservation class mandatory. This is the most suitable because it is just best to help show the generation of entitlement that there is more than just anthropocentric thinking. The youth is so easily manipulated that if someone older tells them something they are forced to believe it because they don't know anybetter. This is why the mandatory class is best to work with. (s_46)

To explore student decisions, I analyzed responses to step 6 of the unit assessment for emergent themes. The four themes that emerged were minimize interaction, cooperation, status quo, and full protection. Just under half of the responses (44%) indicated a desire to minimize interactions between humans and prairie dogs through the creation of a nature reserve for prairie dogs to separate them from agricultural areas or to

exclude prairie dogs from agricultural land through the use of barriers. Just over a third of student decisions were consistent with the cooperation theme (37%), which was characterized by actions seeking to increase acceptance of prairie dogs without removing prairie dogs from the land. This included governmental/educational reform to increase acceptance of prairie dogs, recreational hunting of prairie dogs, and tax incentives for landowners to keep prairie dogs on their land. Very few students came to a decision within the status quo theme (7%) and protect themes (7%). The status quo theme was characterized by listing prairie dogs as a pest species where landowners largely have the freedom to preserve or exterminate prairie dogs on their land without state intervention. The protect theme included actions which sought or required federal/state protection as part of a management option. The remaining students (5%) did not provide a response.

### **2.3.2 Relation Between Abstraction (step 1), Value Orientations, Values in Student Decision-making Processes (step 1 and step 3), and Decisions (step 5)**

To answer my second research question, I first analyzed the human-nature value orientation survey responses (J. I. De Groot & Steg, 2008). Students' value orientations were higher for altruistic ( $M = 4.99$ ,  $SD = 1.38$ ) and biospheric ( $M = 4.95$ ,  $SD = 1.40$ ) value orientations than egoistic value orientations ( $M = 4.87$ ,  $SD = 1.23$ ). There was a moderate positive correlation for the altruistic and biospheric value orientations ( $r = 0.66$ ), meaning that students with higher altruistic tendencies also have high biospheric tendencies and vice versa. There was no correlation between egoistic and altruistic values or biospheric and egoistic values ( $r < 0.20$ ). The bio-ego scores that I calculated (biospheric minus egoistic) had a mean of 1.09 and a standard deviation of 1.76 with two

modes of 1.00 and 1.25.

To answer my question about the relationship between abstraction (step 1), value orientations, values in student decision-making processes (step 1 and step 3), and decisions (step 5), I performed a multinomial logistic regression with two predictor variables, the bio-ego scores and the LCM scores, for each dependent variable (i.e. problem statement value themes, criteria value themes, and decisions).

The overall model predicting the dependent variable of problem statement value themes was significant ( $df = 12$ ,  $\chi^2 = 29.08$ ,  $p = 0.004$ ). The LCM scores ( $df = 6$ ,  $\chi^2 = 23.25$ ) significantly predicted the value themes presented in the problem statements ( $p = 0.001$ ), but the bio-ego score did not. The overall model predicting the dependent variable of criteria value themes was significant ( $df = 12$ ,  $\chi^2 = 25.13$ ,  $p = 0.014$ ). In this model, the LCM scores ( $df = 6$ ,  $\chi^2 = 18.65$ ,  $p = 0.005$ ) significantly predicted value themes expressed in criteria (step 3), but the bio-ego scores did not. The overall model predicting the dependent variable of student decisions was not significant.

To further understand the significant results, I calculated the mean problem statement LCM score for each unique combination of value themes in the students' problem statement and criteria, then sorted by highest to lowest mean LCM scores. I observed that problem statements that contained components of the egoistic value theme (E) had the highest average problem statement LCM scores (Table 2.5). The most common value theme combinations were biospheric (B) ( $n = 19$ ), egoistic (E) and biospheric/egoistic (BE) (both  $n = 15$ ).

*Table 2.5. LCM score by problem statement altruistic (A), biospheric (B) and egoistic (E) value themes when all variables are held constant.*

<u>Theme</u>	<u><i>n</i></u>	<u>LCM score mean</u>	<u>Std. deviation</u>
BE	15	3.39	0.37
AE	2	3.17	0.24
ABE	11	3.09	0.32
E	15	3.07	0.62
AB	4	2.88	0.37
B	19	2.61	0.59
A	7	2.57	0.63

I observed that criteria containing components of the egoistic value themes (E) had the highest average problem statement LCM scores and those containing the biospheric value themes (B) had some of the lowest average problem statement LCM scores (Table 2.6). The most often used value themes within the criteria (step 3) were biospheric/egoistic (BE) ( $n = 33$ ) and altruistic/biospheric/egoistic (ABE) ( $n = 13$ ).

*Table 2.6. LCM score by criteria altruistic (A), biospheric (B) and egoistic (E) value themes when all variables are held constant.*

<u>Theme</u>	<u><i>n</i></u>	<u>LCM score mean</u>	<u>Std. deviation</u>
AE	6	3.50	0.34
E	9	3.06	0.68
BE	33	3.04	0.52
A	2	3.00	0.00
AB	3	2.98	0.87
ABE	13	2.78	0.52
B	7	2.33	0.44

From the three tests I used to explore my second research question, I concluded that LCM scores (a measure of abstraction) have a relationship with the values students use in their problem statement (step 1) and criteria (step 3), but that bio-ego scores (a measure of student values) do not. Upon examining scores for the criteria value themes, I also had an indication that lower LCM scores (more concrete problematizations from step

1) are associated with biospheric value themes.

### **2.3.3 How Does Abstraction in Framing a Problem Relate to Value Orientations (i.e., Egoistic, Altruistic, and Biospheric Value Orientations)?**

To explore potential connections between VBN theory and CLT, I performed a multinomial logistic regression to determine if biospheric, altruistic, or egoistic value orientation survey scores (J. I. De Groot & Steg, 2008) predicated problem statement LCM scores. The multinomial logistic regression model was not significant. Therefore, I performed an additional multinomial regression analysis to compare the bio-ego scores to the problem statement LCM scores, but found no significant relationship between the variables. Therefore, I do not have sufficient evidence to support a connection between the value orientations from VBN theory and the concrete/abstract problematizations from CLT.

## **2.4 Discussion**

### **2.4.1 Characterization of Problematization (step 1), Values in Student Problem Statements and Criteria (step 1 and 3), and Decisions (step 6)**

The variation in ways students problematized the prairie dog issue suggest to us that students have different ideas about what it means to define a problem, which Balgopal et al. (2016) and Bardwell (1991) suggest can happen when addressing environmental issues. Students who have a specific course of action in mind may not be as open to other courses of action or differing views. Students who describe the situation without giving a course of action may be better prepared to listen to differing views and may rely on those to explore potential courses of action. Most student problematizations



included biospheric and egoistic themes, but fewer problematized the issue using the altruistic theme. This issue largely is about the preservation of the prairie ecosystem and financial issues for ranchers/landowners, so this result is not surprising.

The mirroring in the topical themes of the problem statement (i.e., conserving/controlling prairie dogs and the role of prairie dogs/damage they cause) indicate that, given the same information on an issue, the student population as a whole came to two very different alternatives; to relieve the conflict by removing the prairie dogs or to relieve it the conflict by changing landowner impressions of prairie dogs. The least chosen options were characteristic of the extremes where either prairie dogs are treated as pests or prairie dogs are protected. Perhaps students thought preservation of ecosystems and economic development should be balanced, as a similar sentiment expressed by just under half of participants in Sexton et al.'s study indicated (2001). It is also possible to suggest that the desire to have cooperation and minimize interaction was indicative of naïve conceptions about how the issue can be solved in simple ways by accommodating both parties.

#### **2.4.2 Relationship between Abstraction (step 1), Value Orientations, Value Themes in Student Decision-making Processes (step 1 and step 3), and Decisions (step 5).**

I hypothesized that bio-ego scores could help predict values and decisions in the student assessments since this has been observed in the past in this population with other issues (Alred & Dauer, 2016). I did not have evidence that value orientations were related to student decision-making or their ultimate decisions. This may be a result of low self-reported personal relevance of the issue to students resulting in decreased attention to

their decisions and whether they personally valued the decision.

For my hypothesis regarding abstraction of problem statements and value themes presented in their problem statements (step 1) and criteria (step 3), I found that abstraction of problem statements was significantly related to the value themes presented within student problem statements and criteria. For egoistic individuals, the issue may be theoretically and socially distant, especially when they lack experience with the issue, as did most of the students in the course. Students with egoistic themes in their problem statement and criteria may not have sensed that the issue was concrete since the issue was about someone else's money or possessions rather than their own, resulting in high LCM scores. Within criteria, the pattern of biospheric value themes having low mean problem statement LCM scores may have occurred because biospheric value themes are associated with biosphere level concerns, which includes prairie dogs, thereby making the issues more relevant and concrete to those students.

I expected that based on VBN Theory (Stern, 2000), students with pro-environmental decisions would have high bio-ego value scores. I also expected that based on work in CLT by Haden et al. (2012), abstract situations would also be associated with pro-environmental decisions. I did not see either of these associations. Once again, this could be because students in a classroom reported low personal relevance of this topic and their decisions may have been somewhat removed from their true attitudes and beliefs about the topic. An alternative explanation is that although the students defined the problem with a certain level of abstraction, they may not have documented their understanding of the issue as thoroughly or completely as they could have, thereby

providing a problem statement that did not give a very accurate description of the problem they were addressing within their minds. My method of obtaining an abstraction score did not account for the four dimensions of CLT as described by Trope and Liberman (2010), but consideration for the four dimensions (social, spatial, temporal, and theoretical) could help provide better understanding of the patterns I saw with high problem statement LCM scores and egoistic value themes as well as low problem statement LCM scores and biospheric value themes.

#### **2.4.3 How does Abstraction in Framing a Problem Relate to Value Orientations (i.e., Egoistic, Altruistic, and Biospheric Value Orientations)?**

I expected students with low bio-ego scores to have lower LCM scores because an egoistic view focuses on one's self and low LCM scores are associated with concrete situations (Liberman & Trope, 2008; Stern, 2000), but I did not find this association within my study. It is possible that despite low bio-ego scores, these students do not have personal experience with the issue and thus they problematized this issue in abstract ways as happening to someone else, far away from them.

### **2.5 Conclusion**

Through my research, I have uncovered that abstraction in students' problem statements is related to the value themes present in both students' problem statements and criteria when using a formal decision-making framework. Further qualitative exploration suggests that egoistic values are associated with higher abstraction scores and biospheric values may be associated with lower abstraction scores. I did not find a clear relationship between VBN theory and CLT nor did I find clear connections between either of the two

theories and student decisions.

The discovery that students' values as measured by value orientations did not predict their decisions is unexpected. Researchers suggest students base their decisions on their personal values, but this did not appear to be the case in my study. In my study, I did not explore what contributed to these differing results, but researchers have suggested the use of decision frameworks, like the framework adapted from work by Grace and Ratcliffe (2002), Lee and Grace (2010), and Ratcliffe (1997), to increase the quality of decisions, including assessing information and assessing tradeoffs. Future studies could determine the influence of this framework on student decisions by first asking students to articulate a decision without the use of the framework and later asking students to articulate a decision with the use of the framework.

Egoistic value themes within student's problem statements and criteria appeared to be somewhat more associated with high abstraction scores from their problem statements. Biospheric value themes within the criteria appeared to be somewhat more associated with low abstraction scores from their problem statements. The nature of the relationship between abstraction and values is not apparent from this study. My suggestion is that egoistic considerations elicit more abstract thinking and biospheric considerations elicit more concrete thinking. More abstract situations have less relevance to an individual than concrete situations because abstract situations are perceived as being distant socially, spatially, temporally, or theoretically, which creates psychological distance. It is possible that when students mention egoistic values, they must project those egoistic values on a socially and spatially distant entity since they have not had

personal experience with the issue, which results in low relevance and high abstraction scores. Biospheric considerations may elicit more concrete thinking because biospheric values are about harmony between humans and nature, which is connected to abstract social situations. It may be easier for these students to place themselves in the situation in a concrete social way than it is for students utilizing egoistic considerations, which results in high relevance and low abstraction scores.

Understanding the connections between values and abstraction could lead to modifying teaching practices to increase relevance to certain groups of students. For instance, increasing relevance for those who are more inclined toward egoistic considerations by asking them to make decisions as a landowner so they get the impression that it is not someone else's money at risk, it is their own money and that it is not someone else's land that contains prairie dogs, it's their land. The relevance of these issues is of importance because if SSIs are to be beneficial to students, the students need to have the impression that the issue is real and warrants careful consideration. Perhaps this could lead to reformed educational systems where SSIs are not taught through facts, but that they are taught through stakeholder interviews, videos of visitations to grasslands, etc. to make the issue socially, spatially, temporally, and theoretically concrete. After helping the students connect with the issue in concrete ways, they can be given facts that challenge their first inclinations on the issue and given a framework to help them come to an informed decision.

Ultimately, my data does not indicate there is a relationship between level of abstraction in problem statements and student decision. Given differences in students'

problematization in terms of statement type, I suggest instruction be more specific about what it means to problematize an issue and that researchers continue to explore the nature of the relationship between initial problematization of the issue and student decisions. There are, however, indications that level of abstraction is related to values utilized within student work, which may ultimately influence student decisions. Future research may continue to explore the use of LCM and bio-ego scores as interactive terms where theory suggests that high construal (high abstraction) of the problem is related to a stronger connection between an individuals' values and decision-making (Eyal et al., 2009).

## **Chapter III: Sixth Grade Students' Problematization and Decision-Making on a Wind Energy Socio-Scientific Issue**

### **Abstract**

Little is known about middle school students' problematization and framing of wind energy socio-scientific issues (SSIs). I analyzed student artifacts (n=116) from a wind energy unit through the lens of Construal Level Theory (CLT), which suggests concrete thinkers focus on feasibility issues (negative perception), whereas abstract thinkers focus on desirable outcomes (positive perception). My research questions address the following: (1) How do students problematize the SSI along a continuum from concrete to abstract? (2) How do students' concrete or abstract problematization influence their decisions? (3) How do students' perceptions of wind energy relate to the concrete/abstract continuum?

### **3.1 Introduction**

Humans use energy on a daily basis for heating and cooling, lighting, gasoline for transportation, and more (*U.S. energy flow, 2015*). Worldwide, energy production is projected to increase 48% from 2016 levels by 2040 (U.S. Energy Information Administration (EIA), 2016). Human activities, including energy use, are contributors to greenhouse gas emissions, which contribute to climate change (IPCC, 2014). Energy is also fundamentally interconnected with food and water systems, as evidenced by contemporary attention the Food-Energy-Water Nexus (FAO, 2014). The ubiquity of

energy use, projected increase in energy use and its connections to greenhouse gases, climate, and food and water systems, provides compelling reason for all citizens of our global community to have basic energy knowledge and the ability to utilize their knowledge to make informed decisions regarding energy use.

The Next Generation Science Standards (NGSS Lead States, 2013) in the United States are currently being adopted nationwide and are reshaping the K-12 science curriculum. Middle school energy standards include the ability to “obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment” (NGSS Lead States, 2013). Despite these standards, several studies show middle school students do not articulate a robust knowledge of fundamental and applied energy concepts (Bodzin, 2012; DeWaters & Powers, 2011). For instance, only 36.1% of eighth graders could correctly identify natural gas as a nonrenewable energy resource and 42.0% of students correctly identified coal as the most abundant fossil fuel in the United States (Bodzin, 2012). Just over half (56.5%) of the students in the Bodzin (2012) study understood ‘renewable energy resources’ as resources that are replenished by nature faster than they are consumed. DeWaters and Powers (2011) obtained similar scores for middle school students with only 26.6% of students correctly identifying coal as the most abundant fossil fuel in the United States and 50.0% of students selecting the correct definition for ‘renewable energy’ resources. Clearly, there is a need for ongoing efforts to continue to foster energy literacy, and especially renewable energy literacy, with K-12 students to help individuals and communities make informed energy decisions (US Department of Energy, 2012).



To address this need, I engaged in a design-based research and development effort to support 6<sup>th</sup>-grade students' learning and decision-making about wind energy. The limited amount of research on SSI-based energy education, and more specifically wind energy education, at the middle school level prompts the need for a better understanding of student problematization and decisions about wind energy, thus justifying the present study, which is driven by the following research questions:

- 1) How do students problematize a wind energy SSI topically and how abstract is the problem to them?
- 2) How do students' concrete or abstract problematization of wind energy relate to their decision about a wind energy SSI?
- 3) How do students' positive or negative perceptions of wind energy relate to their problematizing of a wind energy SSI along a continuum from concrete to abstract?

### **3.1.1 Background and Prior Research**

**3.1.1a Socio-scientific issues (SSIs).** To improve energy literacy, DeWaters and Powers (2011) recommend students become active members of society who understand and use scientific knowledge in their decisions through engagement with real-life situations in an educational setting. These recommendations align with socio-scientific issue (SSI) curriculum. SSIs provide a context for instruction that helps students develop scientific literacy, including specific types of literacy like energy literacy. SSIs exist around “frontier science” where there is little certainty within the science community on how to address the issue (Kolstø, 2001) that has ethical, moral, and value implication for

society. As such, SSIs require the application of new scientific knowledge to decision-making processes at a personal or societal level using argumentation skills (Sadler, 2004), previous science knowledge, personal values, and morals. The use of scientific knowledge to make decisions about real-world issues, including those about energy, is a crucial outcome of systemic science education efforts (Aikenhead, 2006; DeBoer, 2000; Kolstø et al., 2006; Sadler, 2004). Wind energy is a contemporary SSI which requires a multifaceted understanding (Rosenbloom, 2006) about renewable energy, resource management, social impacts and public attitudes (Krohn & Damborg, 1999; Wolsink, 2007), economics (Blanco, 2009) and environmental impacts (Mann & Teilmann, 2013; Saidur, Rahim, Islam, & Solangi, 2011). However, though it is clear that decision-making practices change throughout childhood and adolescence into adulthood, there is still relatively little research on decision-making practices in adolescents (Jacobs & Klaczynski, 2002).

**3.1.1b Energy Education and Research.** A large portion of renewable energy education has been focused on high school and college-age students on technology concepts (Bhattacharya, 2001; Karabulut, Gedik, Keçebaş, & Alkan, 2011; Keramitsoglou, 2016). There is little research on renewable energy education with K-8 students despite the existence of developmentally appropriate topics for children as young as five (Kandpal & Broman, 2014) and the existence of standards related to the use of renewable energy (NGSS Lead States, 2013). The limited research that has been conducted with middle school students established generalized energy knowledge and attitudes toward generalized energy (Bodzin, 2012; DeWaters & Powers, 2011), but

research on renewable energy for those ages is not prevalent. Some research details problem-solving abilities in middle school students related to energy issues. One example of such research is that on the building of a power plant to solve rising electrical costs in a city. In the power plant SSI study by Rose and Barton (2012), middle school students demonstrated complex thinking by meandering through multiple viewpoints as they assessed the believability of information about the power plant and determined the best course of action. Students ultimately determined that the best solution to costly energy was the development of a power plant that could steady energy costs, but would ultimately not reduce carbon dioxide emissions despite partial use of biomass. In this situation, students decided that the social gain of steadying energy costs was of higher value than other alternatives that would more drastically reduce emissions.

Additional research on environmental decision-making at the middle school level includes a study by Emery, Harlow, Whitmer, and Gaines (2016). This study explored the influence of information and evidence on hypothetical purchasing, consuming, and voting decisions regarding environmental and science-related issues. In this study, students were asked to make a decision about a SSI, given a set of excerpts (e.g., newspaper cutout, graphs, statistics, etc.), and requested to indicate their decision again. Most students did not change their decisions after receiving additional information on the issue they were presented.

### **3.1.2 Theoretical Framework: Construal Level Theory and Problematicization**

In the decision-making process, the initial definition or problematization of an issue will influence the person's ultimate decision influence the solution or decision

reached (Bardwell, 1991). Balgopal et al. (2016) demonstrated that depending on demographics, students might define issues differently. Additional research widely supports that differences in the presentation of issues can influence behavioral intentions and decisions (Gifford & Comeau, 2011; Halverson et al., 2009; Morton et al., 2011).

One potential difference in problematization of issues is construal level, or the level of specificity in which information is presented. A construal is a mental construction of the past and future, other places, other people, and unlikely events (Trope & Liberman, 2010). Without construal, people can only experience what is happening here and now without the ability to remember the past, predict the future, speculate what might have been, or imagine the reactions of other people. A high construal results in very abstract understanding of a person, place, thing, or situation, which preserves only the most important/defining characteristics of it. For instance, a high construal of wind energy is that it is “green.” This generally means it is renewable energy obtained from natural resources and has a lower CO<sub>2</sub> footprint compared to fossil fuels. By calling the energy “green,” the positive environmental impact of using the source is preserved without needing to remember specific details. CLT is comprised of four dimensions - social, spatial, temporal, and theoretical. The concrete condition of the four dimensions refers to a situation happening to oneself, locally, now, and that is a common occurrence. The abstract condition of the four dimensions refers to a situation happening to someone who is unlike yourself, far away, in the future, and that is an uncommon occurrence.

Research on Construal Level Theory (CLT) details how the construal of people, places, and situations influences individuals’ decisions and actions. Previous work in

CLT shows that in distant situations (a high abstraction), individuals are able to generate more pros and fewer cons about actions (Eyal et al., 2004) and that individuals intend to act in pro-environmental ways (i.e. mitigate climate change) rather than adapt to consequences (i.e. adaption to climate change) (Haden et al., 2012). In the context of this research, these previous research findings suggest that students with a more abstract problematization of the issue may have more positive views of the wind farm than those who problematized the issue in more concrete ways.

## **3.2 Design and Methods**

### **3.2.1 Research Design**

This *design-based empirical research* (Edelson, 2002) follows a mixed methods convergent parallel design (Creswell & Plano Clark, 2011a) (Figure 3.1). This research is grounded in a pragmatic worldview (Creswell & Plano Clark, 2011b), which allows for the use of both qualitative and quantitative research methods to explore and find solutions to problems. This approach is common for mixed methods research since emphasis is placed on using the methods, techniques, and procedures that best aid researchers in accomplishing their research (Creswell & Plano Clark, 2011b). Design-based research has a crucial role to play in initial attempts to translate novel, theoretically-informed design principles into concrete educational interventions. Here, I draw upon theoretical constructs and Edelson and colleagues' (2006) Stakeholder Consequences Decision-Making (SCDM) stakeholder-focused SSI-based curricular approaches to develop and test a novel, 3-week wind energy mini-unit. The convergent parallel design provides a means to utilize both student artifacts and interviews to provide a robust characterization

of 6<sup>th</sup>-grade students' problematization and decision-making about this wind energy issue, particularly for the first research question.

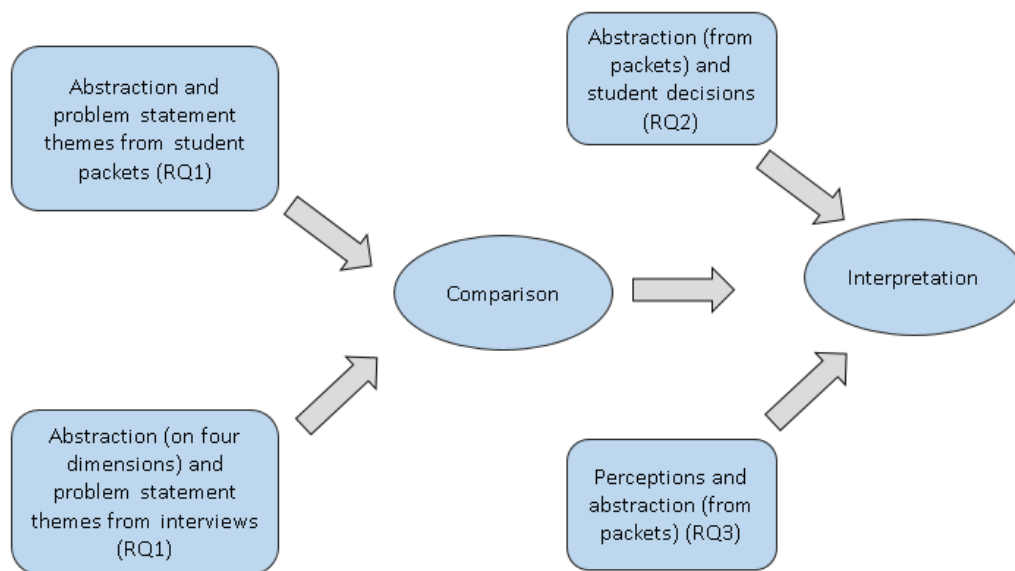


Figure 3.1. Mixed methods research design.

**3.2.1a Participants.** This study included 6<sup>th</sup> grade students (n=116) enrolled in a single public middle school in a Midwestern state. The school is situated in an urban cluster within an agricultural and rural landscape. Students in this school are predominately white and 40% were on free or reduced lunch.

**3.2.1.b Classroom context.** The three-week wind energy mini-unit used for this study was co-developed by three middle school teachers and the research team. The instructors taught the mini-unit at the end of a larger, pre-existing earth and atmospheric science unit at the end of the academic school year. This min-unit contained six lessons designed around a contemporary, local SSI associated with the proposed development of a new wind farm in the landscape surrounding their community.

### 3.2.2 Data Sources and Collection

**3.2.2a Student artifacts.** The first lesson was an introduction to wind turbine technology where students were asked to define (or describe) the issue after receiving limited information from media sources about the proposed wind farm. Students then learned about renewable vs. non-renewable energy and built physical models of wind turbines to better understand the energy potential of wind farms. The remainder of the unit followed the general design of the Stakeholder Consequences Decision-Making (SCDM) process described by (Edelson et al., 2006) where students identified potential stakeholders in the wind turbine topic and how those stakeholders would be impacted by the presence of a wind farm. Most importantly, the students were asked to describe or define the problem. The writing prompt was:

“In this lesson, you learned about the proposed wind farm, some different opinions on it, and some sources of information people might want to use to make a decision about whether the facility should be built. What do you think the problem or challenge is? Please write a description explaining it in your own words. Please consider *what* is happening, *where* it is happening, *who* might be affected, and *why* there are differing opinions on whether the wind farm should be developed.”

Student artifacts were collected and examined at the end of the wind turbine unit, including a definition of the problem, a chart detailing the perceived consequences of the wind farm, a stakeholder impacts chart, and the students’ ranking of the stakeholders of most important to least important with reasoning. The student data also contained an

indication of “yes” or “no” for building a wind farm near their community with their reasoning before discussion (herein referred to as “initial decision”) and after discussion (herein referred to as “final decision”) with the class.

**3.2.2b Student interviews.** I conducted sixteen ( $n = 16$ ) semi-structured interviews (Appendix D) using convenience sampling for those who were willing to be interviewed during the final lesson of the mini-unit. These interviews focused on students’ description of the problem overall and for each of the four dimensions of CLT (i.e. social, theoretical, temporal, and spatial) (Appendix E). Students were also asked to provide further reasoning on their ranking of stakeholder importance.

### 3.2.3 Data Analyses

**3.2.3a Student artifacts.** To answer my questions about topical content of student problem statements, I used QDA Miner Lite to explore emergent themes. To answer my questions about how abstractly or concretely students problematized their problem statements, I used the Linguistic Category Model (LCM) developed by (Coenen, Hedeboew, & Semin, 2006) to assess the use of concrete and abstract language. The LCM manual aids in systematic analysis of a sample of writing for abstraction through the inspection of verb, adjective, and noun usage. I obtained the problem statement LCM score (herein referred to as “LCM score”) by averaging the values assigned to each part of the students’ problem statements using the LCM protocol with some later modifications (Appendix F). The coding was then assessed for inter-rater reliability (IRR) between two coders as recommended by the LCM manual.



For this study, all research questions and kappa scores were analyzed using Statistical Package for the Social Sciences (SPSS). I established IRR between two coders by coding 10% of the sample independently based on initial interpretation of how the rules in the LCM manual were to be applied to student problem statements. There was high IRR ( $\kappa = 0.71$ ) before discussion. After discussion, the coders were able to agree to 100%.

To answer questions relating to student perceptions of wind turbines, I developed a rubric (Appendix F) to code students' problem definition, criteria chart, and stakeholder consequences chart as has having a positive, negative, or neutral/mixed perception. Essentially, I calculated the net positivity or negativity of the problem statement by counting the number of positive statements and subtracting the number of negative statements. I conducted the exact same calculation for the criteria chart and stakeholder impacts chart combined. I weighted the net positivity or negativity the student students' problem statement by multiplying the net number by two because the positivity or negativity in the students' original statement was presumed to factor more heavily into their perceptions than later work. The weighted net positivity or negativity from the problem statement and the net positivity or negativity from the criteria chart combined with the stakeholder chart were added. If this final number was more than +2, the students' perception was positive. If this final number less than -2, the students' perception was negative. If this final number was between +2 and -2, inclusively, the student had a mixed/neutral perception. IRR was high ( $\kappa = 0.941$ ) for a 14.5% sample (17 students).

**3.2.3b Student interviews.** I analyzed the sixteen semi-structured student interviews using QDA Miner Lite for the same emergent themes found within the problem statements students wrote in their packets. I searched for evidence of abstract and concrete problematization of the issue for each of the four dimensions described in CLT (i.e. social, spatial, temporal, and theoretical) (Appendix B) using QDA Miner Lite to provide a qualitative understanding of what dimensions of this issue are abstract or concrete for a random sample of students in the population.

### **3.3 Results**

#### **3.3.1 Characterizing Problematization Topically and in Terms of Abstraction**

In research question #1, I asked, “How do students problematize a wind energy SSI topically and how abstract is the problem to them?” Findings from qualitative analysis of the student packets show that the students discussed a wide variety of topics related to the wind energy issue. Some topics included positive characteristics of wind energy, noise pollution, cost and taxes, and the aesthetics or placement of the wind turbines (see Table 3.1). Cost and taxes were sometimes talked about in positive ways (i.e. they “save” money through lowered taxes or make money from selling the energy), but sometimes in negative ways (i.e. the community pays increased taxes). About a quarter of all the students (26%) mentioned health concerns about wind turbines releasing toxic chemicals or causing cancer. These health concerns may exist from misunderstanding a news article that compared wind turbines to coal plants. More than half the students discussed wind energy as a green or renewable energy, but very few compared wind energy to non-renewable sources of energy.

Table 3.1

*Themes in student packet problem statements.*

<u>Theme</u>	<u>%</u>
Positive characteristics (e.g. green, clean, renewable)	63
Noise pollution	56
Cost/taxes	54
Aesthetics/placement	44
Effects on wildlife	40
Potential to produce energy	40
Social disagreement	27
Health concerns	26
Loss/gain of jobs	22
Reliability	20
Disturbance to farming/ranching	15
Fossil fuel replacement	14
Construction difficulties	5

To further understand the students' problematization of the issue topically, I also explored the students' responses to the interview prompt, "What did you think the problem was at the beginning of the unit?" I noted that many of the themes present in the students' packets were also present in the interviews, so I utilized the themes again for their interview responses (Table 3.2).

Table 3.2

*Themes in interview "what is the problem" responses (n = 16)*

<u>Theme</u>	<u>n</u>
Noise pollution	7
Wildlife impacts	6
Positive characteristics (e.g. green, clean, renewable)	5
Farming/ranching disturbance	4
Cost/taxes	4
Energy production	3
Social disagreement	3

Aesthetics/placement	2
Fossil fuel replacement	2
Loss/gain of jobs	1
Health concerns	1

To understand abstraction in student problem statements as part of my first research question, I explored the students' packet problem statements quantitatively using the LCM and analyzed interviews for indications of abstract or concrete thoughts for each of the four dimensions of CLT (i.e. social, spatial, temporal, and theoretical).

In response to the problem definition prompt in student packets, as a population ( $N = 116$ ), the students were not especially abstract or concrete in their statements ( $M = 2.73$ ,  $SD = 0.67$ ) (Figure 3.2). The lowest abstraction score was 1.00 and the highest was 4.00, meaning that the full range of very concrete to very abstract statements were exhibited by the population. Concrete problematizations focused on directly observable actions with little additional interpretation:

The problem or challeng [sic] is answering peoples question. In the text we read it said that the wind farms are affecting kids imunesystems [sic] and giving them cancer. It also says that the ducks and geese can't see them. It also is giving off a noise that is irritating. (student 02\_65)

Students who problematized the issue abstractly provided additional interpretation into the issue:

I think that the wind farm should be built. I think that the windfarm [sic] should be built so the so the Earth is less polluted. Also I think it should be built because it is more efficiant [sic] than having to pay for over-priced electricity. (student

01\_28)

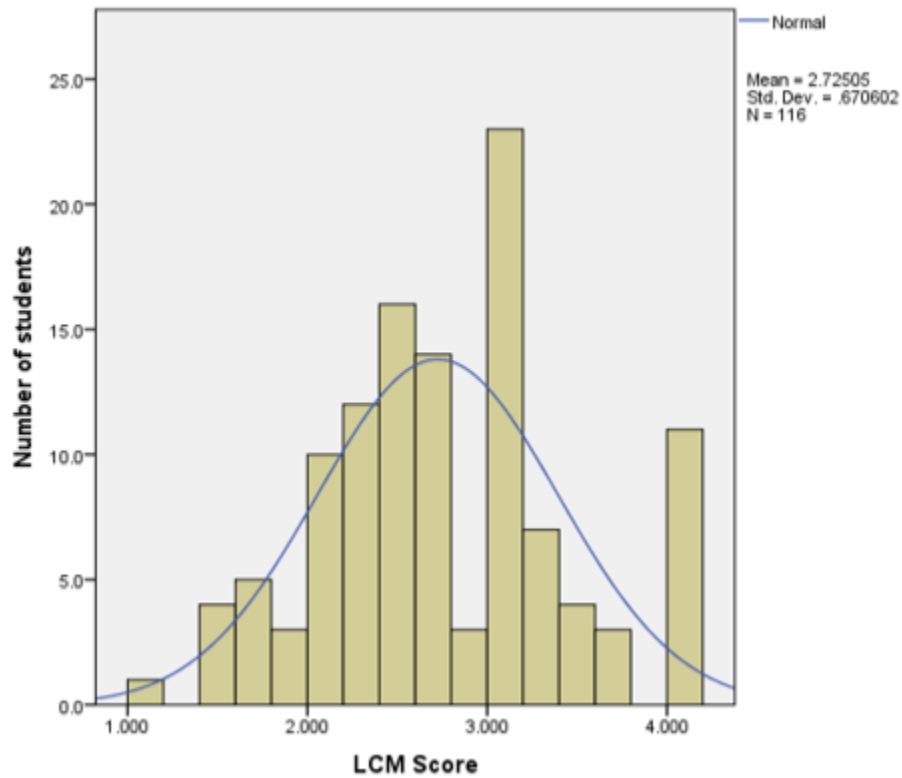


Figure 3.2. Student problem statement abstraction (LCM) scores.

In regards to the interviews on social dimension, eleven of the sixteen students mentioned “we” (a concrete state) in conjunction with the ongoing energy issue that society as a whole must address or an issue that their community must address with the caveat that adults needed to address the problem now (Table 3.3).

Looking at the spatial dimension within the interviews, only four of the sixteen students indicated that the wind energy issue was close to them (Table 3.3). Three students indicated the issue did not matter to them because they lived in the city or did not live near a farm. Two students indicated a mix between it being near and far from them. Students appeared to believe that the issue was near them only if they lived in the

county and saw the wind turbines. Students living in the city did not believe the issue was happening near them, although identifying themselves as part of a larger region (i.e. a state) with wind turbines could give them the impression that they were near the turbines.

In the interviews regarding the temporal dimension, five of the sixteen students thought the issue was happening only now, four thought it is only a problem of the future, and seven thought it was both (Table 3.3). Students who thought the problem was happening now often rationalized that, if solved now, it would not need to be solved in the future. It seems likely that these students were thinking about whether or not this specific wind farm should be built rather than the larger energy and pollution issue. Those who indicated it was a problem of the future discussed how they may have to address the energy/turbine development issues themselves in the future or because these issues will be larger in the future than they are now. Students who indicated this problem was occurring now and in the future discussed this specific wind development proposal and ongoing energy issues or issues with future wind farm developments.

In the interviews regarding the theoretical dimension, thirteen students of the sixteen students felt the issue wasn't real or that it wouldn't be addressed by themselves or would only be addressed by themselves under specific circumstances, indicating what I considered to be abstract (Table 3.3). Four of the students indicated that they thought the issue was real (a concrete state).

Table 3.3

*Dimensional abstraction of interview responses to “what is the problem” prompt.*

	Abstract		Concrete		Mix	
Dimension	Examples	N	Examples	N	Example	N
Social	-they [people or adults] can help with global warming	3	-I don't think it's our future of energy source...[but it's] the best idea of what we have right now (01_64)	10	- it's important if we put it up b/c it would help other families... it's more important for the adults and stuff that pay for it than us [students] right now (01_55)	1
Spatial	- I don't think it's that important because I don't live close to them and I don't know where they're located [in my community] right now (01_59)	3	- it's so close to us (01_52) - let's say I lived somewhere that wasn't Nebraska, it probably wouldn't really affect me (01_65)	4	-I don't technically live in [the community]...I live like four miles away from the turbines (01_64)	2
Temporal	-[we should] address [the issue] in the future because the atmosphere can get worse (01_63)	4	- I think it's more of an issue right now because... if it's more of an issue now, then it's not going to be able to happen in the future (01_58)	5	- looks like we're trying to figure out if we should do it or not right now, but the debate can go on in the future, also, taking them down and putting new ones up (01_55)	7
Theoretical	- I don't really see it being much of an issue unless people start to complain (01_50)	13	-I think it was real (01_52)	4		0

*Note.* Brackets are added by author for clarification. Numbers for each dimension may not add to 16 if there were uncodeable responses.

### 3.3.2 Abstraction and Student Decisions

In research question #2, I asked, “How do students’ concrete or abstract problematization of wind energy relate to their decision about a wind energy SSI?” For the population of students ( $n = 116$ ), over half (57%) of the students indicated an initial decision of “yes” and 41% indicated an initial decision of “no” in their student packets. A small percentage of students (2.5%) indicated no definitive initial decision. Additionally, most (92%) of the students maintained their initial decision as their final decision, with just 6% changing their response and 2.5% of students moving to a decisive stance from an initially indecisive stance. No students at the end of the unit were indecisive.

I performed a one-way ANOVA ( $\alpha = 0.05$ ) on the initial student decisions with regard to LCM scores and discovered there was no statistical difference  $t(112) = -1.498, p > 0.05$ . I continued to explore the influence of abstraction on student decisions by running another one-way ANOVA ( $\alpha = 0.05$ ) to look for potential differences in LCM scores based on whether students maintained their initial decision or changed their response after discussion with the class. There were no differences in abstraction (LCM scores) for students who changed their decision and those who did not  $t(112) = 0.9268, p > 0.05$ .

### 3.3.3 Abstraction and Perceptions of Wind Energy

In research question #3, I asked, “How do students’ positive or negative perceptions of wind energy relate to their problematizing of a wind energy SSI along a continuum from concrete to abstract?” I performed a one-way ANOVA ( $\alpha = 0.05$ ) for the three wind energy perceptions (positive, negative, and mixed/neutral) with regard to



the problem statement LCM scores. The results were significant [ $F(2, 1) = 4.12, p = 0.019$ ] meaning at least one of the conditions had a mean that was statistically different from the rest. A post hoc Tukey Honest Significant Difference revealed the LCM score mean for the negative ( $M = 2.57, SD = 0.65$ ) and neutral/mixed ( $M = 3.09, SD = 0.66$ ) conditions were significantly different from each other ( $p = 0.017$ ) and that the positive perception ( $M = 2.77, SD = 0.65$ ) was not significantly from either the negative or the mixed/neutral perception ( $p > 0.05$ ). From this, I know that students with a negative perception had problem statements that were more concrete than students with a positive perception of wind energy. I can also observe that students with mixed/neutral perception had the highest LCM scores of all.

Students with mixed/neutral positions said things like:

I believe that wind farms are a great idea. Although there are some bad things about it like how they are noisy and a pain to look at, there are too many good qualities to them too. They are a great way to create electricity without polluting the atmosphere. It will help prevent diseases [sic] from spreading [sic] as well. Overall, wind farms are an idea that I like. (01\_10)

If we have wind farms that means the air is not be polluted [sic] as much and fresh air. But on the otherside [sic], it would be hard to farm and it'll scare animals. (01\_37)

There is a large amount of interpretation (indicative of abstraction) in all these statements. For instance, saying the turbines are “a pain to look at” or that they are “a great way” to produce energy or the turbines make it “hard to farm”.

Negative individuals, in contrast, talked about many more observable actions. For instance:

What I think the problem or challenge is is [sic] where are we going to get that much money? If we are going to build 54 wind turbines in just [two nearby counties] then I would think that would cost alot [sic] because you're going to have the people who complain about the noise and the height of them. Then you actually have to get people to sign the papers to let the workers put it on their property. I think that birds are going to be affected the most because there are going to be those over 400 foot tall turbines in the air and they could run into them and die. (01\_56)

Another student stated:

I think that there would be some challenges, but if you can get the time and effort to do it, it can be done. The challenge is that people will complain about it and not like the idea. Others will fully support it. It could affect the people who live nearby. They might not like it. This is being built where a lot of people live. A lot of people have different mindsets on what they think should happened what shouldn't. I think it is a pretty good idea. (01\_57)

In some sense, these negative individuals were merely reporting what they could observe.

### **3.4 Discussion**

My objective of this study was to characterize sixth grade students' problematization of a wind energy SSI, the level of abstraction students used in their

thinking, and how the abstraction relates to their decisions and perceptions to fill a gap in the literature on problematization of issues and its potential influences on decision-making. My results suggest that students have a very dynamic view of the wind energy issue and utilize both abstract and concrete ideas to formulate an understanding of the problem. I did not have indication that the abstract or concrete problematization had a connection with students' decisions or their change in decision after discussion. However, I did have indication that there was a relationship between students' perceptions of wind energy and their abstract/concrete problematizations.

### **3.4.1 Characterizing problematization topically and in terms of abstraction**

In research question #1, I asked, "How do students problematize a wind energy SSI topically and how abstract is the problem to them?" My research on themes within student problem statements (in packets and interviews) on the wind energy issue helps fill a gap in literature regarding sixth grade students' problematization of the issue. In the interviews, the six most often mentioned themes were positive characteristics (i.e. clean, green, etc.), noise pollution, cost/taxes, aesthetics, effects on wildlife, and potential to produce energy. In the interviews, a slightly different order of the six most mentioned themes occurred: noise pollution, effects on wildlife, positive characteristics, cost/taxes, and disturbance to ranching. The themes in the student interviews corroborate those in the student written work. I see the themes as evidence that the students are addressing wind energy as a multifaceted issue (Rosenbloom, 2006). My qualitative exploration of abstraction in student interviews on the four dimensions of CLT show how students can explore the issue in both abstract and concrete ways. At times, the students would

navigate between abstract and concrete thinking to better understand or explain the issue.

The range of abstraction scores I observed in student problem statements within their packets demonstrate that there is no uniform level of abstraction that students use when addressing the wind energy issue. Most students used a mixture of abstract generalizations and concrete details, which could be a result of information they received or their own mental processes as they navigate the issue. I do not have data to say which it is. Either way, the student population considers both abstract generalizations about the problem and specific observable details in attempting to define the issue. The combination of different levels of abstraction and topics leads to the conclusion that these students will navigate the issue in complex ways like they do with other energy SSIs (Rose & Barton, 2012).

### **3.4.2 Abstraction and student decisions**

In research question #2, I asked, “How do students’ concrete or abstract problematization of wind energy relate to their decision about a wind energy SSI?” Just over half of students indicated that the wind farm should be built in their community. Previous research (DeWaters & Powers, 2011) on student attitudes toward renewable energy were also favorable, even when told energy costs would increase. Students largely did not change their decisions, which is similar to that of other studies on middle school students (Emery et al., 2016). Results show that how concrete or abstract students initially described the problem was not linked to their initial decision nor their change in decision. This finding is different from what I expected based on previous research (Eyal et al., 2004; Liberman & Trope, 1998) and research on problematization and decisions

(Halverson et al., 2009; Morton et al., 2011) where high abstraction scores are associated with thinking about positive outcomes (potentially leading to a response of “yes”) and low abstraction scores are associated with thinking about negative outcomes (potentially leading to a response of “no”). I also expected student decisions to be more likely to stay the same if they thought in very abstract ways since abstraction is associated with maintaining essential characteristics of the problem, which would presumably not change throughout the unit. However, student interviews revealed that students would sometimes view the issue as though they were someone who was impacted more extensively by the wind farm. This meant that the student packets, which I presumed represented their understanding of the problem, might not have fully portrayed their thinking on the issue in terms of abstraction.

Based on my results, I cannot provide recommendations on the best teaching strategies in terms of encouraging abstract or concrete thinking, but prior research suggests that problems occurring far away spatially and socially encourages creativity in solving problems (Jia, Hirt, & Karpen, 2009; Polman & Emich, 2011). Concrete thoughts can heavily constrain solutions available because feasibility becomes the largest concern and the general features of the problem are not the focal point (Liberman & Trope, 2008).

### **3.4.3 Abstraction and perceptions of wind energy**

In research question #3, I asked, “How do students’ positive or negative perceptions of wind energy relate to their problematizing of a wind energy SSI along a continuum from concrete to abstract?” The progression of LCM means for each perception suggested that students who conceptualized this wind energy issue most

abstractly were the least likely to commit to a specific decision. My results for the perception of wind turbines based on student abstraction scores differed from research by Eyal et al. (2004) where individuals with higher abstraction were able to identify more positive outcomes than negative. Perhaps students with neutral/mixed perceptions have higher abstraction scores because they are interpreting the issue from multiple viewpoints whereas neutral or positive individuals are considering a narrower range of information that supports their own views in a more concrete way. Another way to think of this is that students with mixed/neutral perceptions are still problem-solving and thus have kept the problem as abstract as possible for the best opportunity to find a solution.

### **3.5 Conclusion**

My motivation to conduct this research is because little research exists on energy topics at the middle school age. Research on middle school students' energy knowledge demonstrates that students do not perform well in terms of knowledge or attitudes (Bodzin, 2012; DeWaters & Powers, 2011). I demonstrated that 6<sup>th</sup> grade students thought about the wind energy issue in a very dynamic way – considering both social and scientific evidence. The researchers and instructors thought this issue would be highly relevant and compelling to the students given the relatively small distance between their community and the development site. However, even with this spatial closeness, students had to talk about the issue as though they were adults because this particular development at the present time was abstract to the students. The students indicated they had some level of responsibility in the wind energy issue, which is also reflected by other studies on generalized energy-related choices and actions (DeWaters & Powers, 2011).

There was indication that mixed/neutral perceptions of wind turbines had higher abstraction than negative perceptions. Abstract thinking is thought to be associated with problem-solving, which may suggest the students with mixed/neutral perceptions are still trying to understand the issue in the broadest way possible to facilitate problem-solving. It is unknown if this is beneficial for students' decision-making or not, although research suggests that abstract thinking can result in more creative problem-solving (Jia et al., 2009; Polman & Emich, 2011).

Encouraging mixed/neutral perceptions through the use of abstract information could keep students in a more creative problem-solving mode that will encourage novel ideas. Later, concrete information could be provided to help students move into a more decided stance where they are expected to support their ideas with specific information. A viable pathway for continued research on perceptions and abstraction is to create an instructional unit that begins with abstract characteristics of the problem during introduction units and later provides students with specific facts to support evidence-informed decisions on the issue as they argue for a course of action.

## Chapter IV: Conclusion

Continuations on my research would be to investigate the link between problematization and decisions further. I could do this by performing statistical analyses on my current data sets for connections between topical theme and ultimate decision. This clearly would not make use of CLT, but nevertheless, extensive research on framing and recommendations made by researchers (Bardwell, 1991; Chang, Zhang, & Xie, 2015; Chong & Druckman, 2007; Gifford & Comeau, 2011; Halverson et al., 2009; Jacoby, 2000; Morton et al., 2011; Nelson, Clawson, & Oxley, 1997; Spence & Pidgeon, 2010; White, MacDonnell, & Dahl, 2011; Zwickle, 2014) suggest this is a worthy line of research.

An additional continuation on my current data set may be to conduct interviews for the prairie dog undergraduate study to further understand students' problematization and motivations to include certain criteria or information in their problem statements (step 1) from their unit assessments. Interview data on students' conceptions of the prairie dog issue could yield additional information similar to the 6<sup>th</sup> grade data where written artifacts do not necessarily convey the full extent of student problematizations. Furthermore, this research could be improved by either finding or developing a Likert-scale survey to determine how abstract or concretely students identify the problem. IRR on the LCM scores was acceptable, but certainly not as high as desired in either study, suggesting the results of these studies might not be replicable. Self-reported conceptions by the students using a Likert-scale survey would not require as much interpretation on the researchers' part and may make the results more easily replicable.



The broader objective of my research projects on undergraduate and 6<sup>th</sup> grade students is to improve scientific literacy, which is defined by science-informed decision-making. The broader story here may be that students must consider issues in both abstract and concrete ways. Abstraction is necessary to encourage novel problem-solving without overwhelming the individual with details, however concrete facts and information about the specific situation are needed to address the specific issue. Throughout decision-making on SSIs, the students need to truly connect with the issue in social, spatial, temporal, and theoretical ways so it will be relevant to them. The way this appears to be possible is not by choosing issues that appear as though they must be relevant to the students, but to encourage students to explore the issue as though they are in the midst of the problem.

Future research could include specific manipulations of the presentation of the issue. For instance, a comparison of five different information presentation treatments (a control where abstraction of materials is not manipulated, a treatment providing only abstract information, a treatment with only concrete information, a treatment with abstract information followed by concrete information, and a treatment with concrete information first and abstract information after). Students would be presented with the same information, but with different abstraction treatments (for instance, abstract information would be to say the situation [whether the prairie dogs or wind turbines] is expensive and the concrete information would be statistics on the cost) and the abstraction of their problem statements could be measured using the Linguistic Category Model (LCM) and their decisions binned. This sort of study would help isolate what

decisions students make in response to concrete or abstract information and also give an opportunity to assess which treatment encourages higher use of specific facts to support their decisions. Other extensions could be to try various aforementioned treatments and use a validated research tool for determining relevance of the issue to students. This sort of study would give indication if abstract, concrete, or a combination of the information results in higher relevance to the students.

Another way to approach future research is to isolate and manipulate individual dimensions within Construal Level Theory (CLT). For instance, the spatial dimension could be manipulated by presenting the same information to students, but placing the situation within a mile of their location or in another country. The social dimension could be manipulated by giving students the scenario where they are told to take the role of a landowner or the role of a person who has been asked to consult on the issue, but who isn't directly affected by the situation. For these studies, outcomes such as relevance, decision type, and abstraction of their problem statements could be measured.

Considerable research still needs to be conducted in regards to problematization and student decisions and decision-making processes. I have provided several suggestions for continuing research, of which manipulation of materials given to students (an experimental approach) is a primary suggestion. Further research in these areas could be of great aid in improving educational teaching strategies to encourage creative decision-making followed by proper support and reasoning of decisions, both of which contribute to science literacy objectives on decision-making. In a rapidly growing world, it is important to use this research and future research to provide tomorrow's leaders with

the best education available.

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## Appendix A

Name: \_\_\_\_\_ Group: \_\_\_\_\_ Instructor: \_\_\_\_\_ LA: \_\_\_\_\_

AGRI/NRES 103 Prairie dogs due: Friday March 11th, 2016 by 10 pm uploaded to Blackboard (35 points)

### LEARNING ASSISTANT RUBRIC

#### Unit Assessment Part I

#### Socioscientific issue: What should we do about prairie dogs in Nebraska?

##### Evaluating arguments in the media (25 points)

*In Kansas, a line is drawn around a prairie dog town.* New York Times by Felicity Barringer, December 11, 2006

Read and evaluate this popular media article. Identify the main claim in the article, which is the “theme” or “thesis” of the article. Identify the evidence in the article, which are statements and reasoning that support the claim.

1. (2 points) Identify the main claim in the article:

*0 – does not make a claim, or makes an inaccurate claim*

*1 – makes an accurate but vague or incomplete claim*

*2 – makes an accurate and complete claim*

*The claim is something along the lines of:*

*Prairie dogs are desirable for some farmers because of their ecological standing, but laws can unfairly allow the state to poison prairie dogs to protect property rights of neighbors.*

2. (6 points) What is the evidence provided to support this claim? In the **first column** provide 3 lines of evidence in the article. In the **second column** explain if you think the evidence is weak or strong and considering the following: Is the evidence or argument valid? Is the evidence *scientific* evidence with peer-reviewed sources? Is the person supporting the claim with fast or slow thinking? Is the argument complete and specific? Can you think of a weakness in the argument? What could they do to make the claim stronger?

Evidence provided in support of this claim:	Is the evidence weak or strong? Why?
A. <i>0 – The student cannot think of supporting evidence.</i> <i>1/2 – The student gives supporting</i>	<i>0 – The student only says that the argument is weak or strong, but does not support it.</i> <i>1/2 – The student says that the argument</i>

<p><i>evidence with unclear connection and reasoning.</i></p> <p><i>1 – The student gives supporting evidence with clear connection and reasoning.</i></p>	<p><i>is weak or strong and supports it with unclear reasoning.</i></p> <p><i>1 – The student says that the argument is weak or strong and supports it with clear reasoning.</i></p>
<p><b>B.</b></p> <p><i>0 – The student cannot think of supporting evidence.</i></p> <p><i>1/2 – The student gives supporting evidence with unclear connection and reasoning.</i></p> <p><i>1 – The student gives supporting evidence with clear connection and reasoning.</i></p>	<p><i>0 – The student only says that the argument is weak or strong, but does not support it.</i></p> <p><i>1/2 – The student says that the argument is weak or strong and supports it with unclear reasoning.</i></p> <p><i>1 – The student says that the argument is weak or strong and supports it with clear reasoning.</i></p>
<p><b>C.</b></p> <p><i>0 – The student cannot think of supporting evidence.</i></p> <p><i>1/2 – The student gives supporting evidence with unclear connection and reasoning.</i></p> <p><i>1 – The student gives supporting evidence with clear connection and reasoning.</i></p>	<p><i>0 – The student only says that the argument is weak or strong, but does not support it.</i></p> <p><i>1/2 – The student says that the argument is weak or strong and supports it with unclear reasoning.</i></p> <p><i>1 – The student says that the argument is weak or strong and supports it with clear reasoning.</i></p>

*Evidence that we've noticed in this article includes:*

- a century-old state law allows the county to send exterminators onto the Haverfield and Barnhardt ranches against the owners' wishes, but at their expense, to protect local property values*
- the laws reflect a persistent belief that the prairie dog is not a valued remnant of the short-grass prairie of the past, but a despised pest that eats grass needed to fatten cattle*
- property lines tend to be incompatible with the prairie dogs' age-old practice of digging new holes and expanding their tunneled colonies across the landscape*
- the Haverfields do not want prairie dogs poisoned en masse.*
- rotation grazing can accommodate both cattle and rodent, improve the soil and the grass, and promote the return of those species drawn either to prairie dogs' abandoned holes (such as burrowing owls and badgers) or to their flesh (foxes, rattlesnakes, hawks, and eagles).*
- Mr. Sowers says the prairie dogs are devaluing his property as they move their young to his land.*
- The county appraiser reported that grassland with prairie dogs brings in less money when rented out because prairie dogs and cattle compete for grass.*
- Mr. Sowers feels ranching near a prairie dog town is similar to living by a halfway house*

*in an urban setting.*

*-Mr. Sowers 9000 acre property had only 10 acres of prairie dog town when he got it, but now the colony has 500 acres of prairie dogs. He blames Mr. Haverfield's prairie dogs.*

*-Jonathan Proctor questions why a native of the Great Plains that once covered billions of acres cannot have a few thousand acres.*

*-Black-footed ferret could be reintroduced to the Haverfield land.*

*-Mr. Haverfield suggested a 90 foot buffer zone of poisoned land with an electric fence to control the prairie dogs from going to Mr. Sowers land.*

*-Someone applied Rozol to Mr. Barnhardt's land without his permission.*

*-Cattle were placed near the Rozol application to stop poisoning (because Rozol near cattle is illegal) and now more expensive gas around the cattle to control the prairie dogs.*

**Reminder:** ways to evaluate online materials:

- **Relevancy:** the information's level of importance to a particular reading purpose or stated information need
- **Accuracy:** the extent to which information contains factual and updated details that can be verified by consulting alternative and/or primary sources
- **Reliability:** the information's level of trustworthiness based on information about the author and the publishing body
- **Bias (perspective):** the position or slant toward which an author shapes information

3. (4 points) Is the information in the article **relevant** to how to resolve the prairie dog problem in Nebraska? How is it relevant or irrelevant? Support your idea using specific details about the article or quotes.

*0 – The student only says that it is or isn't relevant, but does not give specifics about how it is relevant to the issue.*

*2 – The student says that it is or isn't relevant, and vaguely explains about how it is relevant to the issue.*

*4 – The student says that it is or isn't relevant, and is clear and specific about how it is relevant to the issue.*

*Note: The student should probably talk about the people discussed in the article and how we perhaps have a similar situation in Nebraska with people who want to have prairie dogs and others who want "good neighbor laws".*

4. (4 points) Is the information in the article **accurate**? How is it accurate or inaccurate? Support your idea using specific details about the article or quotes.

*0 – The student only says that it is or isn't accurate, but does not give specifics about how.*

*2 – The student says that it is or isn't accurate, and vaguely explains about how.*

4 – The student says that it is or isn't accurate, and is clear and specific about how.

*Note: The student should probably talk about how easy it would be to verify the claims made by the land owners and county commissioners mentioned in this article.*

5. (4 points) Is the information in the article **reliable**? How is it reliable or not reliable? Support your idea using specific details about the article or quotes.

0 – The student only says that it is or isn't reliable, but does not give specifics about how.

2 – The student says that it is or isn't reliable, and vaguely explains about how.

4 – The student says that it is or isn't reliable, and is clear and specific about how.

*Note: The student should probably talk about the source of the article and how reliable each person's knowledge about prairie dogs might be.*

6. (4 points) Is the information in the article **biased**? How is it biased or not biased?

Support your idea using specific details about the article or quotes.

0 – The student only says that it is or isn't biased, but does not give specifics about how.

2 – The student says that it is or isn't biased, and vaguely explains about how.

4 – The student says that it is or isn't biased, and is clear and specific about how.

*Note: the student may take this question as the bias of any of the people discussed in the article, or it may talk about the bias of the author of the article. The author of the article appears to have very little bias because they present both sides of the disagreement. Student thoughts on the bias of individual people in the article may be more varied depending on what things the students believe the people did or did not consider while formulating their opinions on prairie dogs.*

7. (1 point) Overall is the information in this article trustworthy? Why or why not?

Support your idea using specific details about the article or quotes.

0 – The student only says that it is or isn't trustworthy, but does not support it with clear reasoning and appropriate quotes.

1 – The student says that it is or isn't trustworthy, and supports it with some clear reasoning and some appropriate or inappropriate quotes.

2 – The student says that it is or isn't trustworthy, and supports it with clear reasoning and appropriate quotes.

### **Examining a Scientific Article (10 points)**

Derner, Detling, and Antolin (2006) *Are livestock weight gains affected by black-tailed prairie dogs?* *Frontiers in Ecology and the Environment*.

8. (6 points) Examine the scientific journal article, Derner et al. (2006), to learn more

about how scientists formulated one of the scientific arguments that was then cited by the media article.

***You do not have to read the entire article.***

- A. (1 point) Who authored the study and at what institution do the authors work?
  - a. *Justin Derner – High Plains Grasslands Research Station*
  - b. *James Detling - Colorado State University*
  - c. *Michael Antolin – Colorado State University*
- B. (1 point) What is the claim of the study (usually concisely described in the abstract)?
  - a. Livestock weight gains decreased linearly, but at a rate slower than the rate of colonization by black-tailed prairie dogs. (And this decrease in livestock gains resulted in lower estimated economic returns)
- C. (1 point) What is the evidence as described in the abstract as it links to the claim?
  - a. Pastures with 20% of area occupied by prairie dogs reduced the estimated value of livestock weight gain by \$14.95 per steer and by \$2.23ha<sup>-1</sup>. In pastures with 60% occupancy, reduced livestock weight gain lowered estimated value by \$27.91 per steer and \$4.47ha<sup>-1</sup>, or about 14%.
- D. (1 point) Describe the data that was collected in the report (look in the methods for sample size, data collection methods, models and parameters used).
  - a. The scientists measured the perimeter of the four colonies with a handheld GPS unit. Prairie dog densities were estimated over 4 days using plot-based visual methods. Seasonal weight gain was determined by weighing individual animals at the beginning and end of each grazing season.
- E. (1 point) What is the “scope” of the journal, or, what is the journal “about?” (Navigate to the journal’s home website and click on “general information.”)
  - a. Current ecological issues and environmental challenges. It is aimed at professional ecologists and scientists in related disciplines that focuses on global issues, broadly impacting research, new techniques/technologies, new approaches to old problems, and practical applications of ecological science.

*A-E. Correct and complete details about the study*

9. (2 points) Sometimes it can be difficult to determine from a journal’s webpage if they are peer-reviewed. One way to definitively know if a journal is peer-reviewed is to use Ulrich’s database (<http://0-ulrichsweb.serialssolutions.com.library.unl.edu/>).

Is the Derner et al (2006) journal peer-reviewed? What implications does the peer-review process have on the reliability or bias of the article?

*0 – The student only says that there is or isn't a bias, but does not support it with clear reasoning.*

*1 – The student says that there is or isn't a bias, and supports it with some clear reasoning.*

*2 – The student says that there is or isn't a bias, and supports it with clear reasoning*

*For example: "No, I don't think there is a bias because the scientists are reviewed by other scientists who specialize in the same subject. This review process prevents a person from pushing their own bias or agenda because the other scientists in the field must agree with the study results."*

10. (3 points) What do the authors say about uncertainty or limitations in the scientific article (look at the "general discussion" section to see what the scientists point out)? Explain.

*0 – Incorrect or no reporting on what the scientists say in the article*

*1.5 – Some incorrect or no reporting on what the scientists say in the article*

*3 – Correct reporting and full explanation of what the scientists say in the article*

*The expansion rate of the prairie dog towns exceeded that of prairie dog cites studied by others. Prairie dog expansion rates are drastically different depending on the town. Their study was limited in time-scale, so the effect of prairie dogs may be different on a larger timescale.*

## Appendix B

1) [2 points] How much have prairie dog population numbers declined by since European settlement? (Circle one)

- A. 5%
- B. 75%
- C. 77%
- D. 95%**

2) [2 points] According to *Prairie conservation in North America*, what are some of the major concerns about prairie habitat loss? (**circle all that apply**)

- A. Higher potential for species extinction on remaining grassland**
- B. Losing the ability grassland plants have to reduce CO<sub>2</sub> in the atmosphere (carbon sinks)**
- C. Invasion of non-native species that cause economic harm
- D. Loss of vegetation causing another Dust Bowl

3) [2 points] What is a keystone species? (**circle one**)

- A. An omnivore that eats animals lower on the food chain than it, but that is eaten by animals higher on the food chain than it.
- B. A species which has a disproportionately large role in an ecosystem given its abundance.**
- C. A species which creates key-shaped holes in stones.
- D. A species that is especially susceptible to environmental changes and is used to indicate the health of an ecosystem.



4) [2 points] Rank the species from most dependent [1] to least dependent [4] on prairie dogs.

- 3   Coyote
- 1   Black Footed Ferret
- 2   Burrowing owl
- 4   Wolf

5) [2 points] What does Nebraska law dictate or imply? (**circle all that are true**)

- A. Black-tailed prairie dogs are on the federal threatened and endangered species list, so people cannot kill or harass them
- B. Prairie dogs cannot be hunted recreationally
- C. **Prairie dogs are agricultural pests**
- D. **Landowners must prevent the spread of prairie dogs to other properties**
- E. **You cannot release an animal more than 100 yards from where it was found**
- F. **Nebraska Game and Parks Commission are responsible for managing all wildlife, including prairie dogs**

6) [2 point] Match the management practice with the land ethic.

  C   Killing thousands of buffalo for conveyor belts.

a. Utilitarian

  A   Hunting deer to use for food and to manage the population size

b. Stewardship

  D   Setting aside land to preserve it from the influence of people

c. Economic

  B   Allowing grasslands to burn to encourage native plant species

d. Protectionist

7) [2 points] Why are black-tailed prairie dogs not protected federally? **Provide at least 2 reasons.**

**Black-tailed prairie dogs have sufficient numbers as of now according to**

scientific studies. **Black-tailed prairie dogs might be killed off quickly before gaining protection because of poor public perception. Black-tailed prairie dogs recover from the plague after several years, so disease is not of high concern.**

8) [2 points] Which of the following are reasons for prairie dog decline? **(circle all that apply)**

- A. cannibalism (prairie dogs are eating other prairie dogs)
- B. habitat loss**
- C. disease**
- D. human control methods**

9) [2 points] What is true about the use of poison control on prairie dog towns? **(circle all that are true)**

- A. It is 100% effective
- B. It can harm non-target species**
- C. The control costs can exceed the benefit**
- D. All types of poison are legal

10) [5 points] Match the year to the major historical milestones **[you may use years more than once or not at all]**

- A. early 1900's **\_\_\_D\_\_\_** up until this time, all state and federal agencies handled prairie dogs as pests
- B. 1960's **\_\_\_A\_\_\_** complete eradication of prairie dogs is encouraged
- C. 1970 **\_\_\_D\_\_\_** prairie dogs were submitted as a candidate for federal protection
- D. 2000 **\_\_\_C\_\_\_** poisoning of prairie dogs is no longer allowed on federal land
- E. 2015 **\_\_\_B\_\_\_** a shift toward maintenance of prairie dog populations begins, prompted by things such as *Silent Spring*

11) [2 points] What are the guiding principles in our management practices according to the Public Trust Doctrine and North American Wildlife Conservation Model? **(circle all that apply)**

- A. Everyone owns the native animals found within the United States, not just the property owner where the animals reside. The government manages the animals for the public and for future generations.**
- B. You may only kill certain wild animals for food, self-defense, and property**

**protection. You cannot kill for no reason.**

**C. Management decisions should be made based on scientific data.**

**D. You cannot transport wildlife across state borders.**

### Appendix C

Name: \_\_\_\_\_ Group: \_\_\_\_\_ Instructor:  
 \_\_\_\_\_ LA: \_\_\_\_\_

AGRI/NRES 103 Prairie Dogs UA4 Due: Friday March 18<sup>th</sup>, 2016 by 10 p.m. uploaded to Blackboard (40 points)

## RUBRIC VERSION

### Part II (40 points): Slow-thinking Decision-making Framework Prairie Dogs

In this class you've read articles about this issue and you have had group and class discussions about prairie dog keystone status, prairie dog conservation, and prairie dogs as pests. Now take some time to use the "Slow thinking framework: steps for high quality decision-making" to outline your thoughts about the issue. Your thoughts below should be more clear and thought-out than what you did for group work in class, and will be graded more rigorously. What you write below should represent your own thinking, which may vary from the thinking of your group.

**1. Define the issue (2 points).** YOU define the problem, then work through the rest of this assignment in the context of your definition of the problem. What is the problem that needs to be solved?

*0 – student does not describe the issue*

*1 – student defines the issue or problem vaguely*

*2—student defines clearly and specifically the issue or problem in Nebraska*

**2. Options (6 points)** - List or identify the possible alternative courses of action in considering the problem or issue. Identify at least 3 distinctly different and viable options.

*0- student does not describe more than one distinctly different option, or the options are outlandish and non-viable*

*3- student does not describe more than two distinctly different options, or one of the options is extremely unlikely*

*6 – student describes three possible and distinctly different options. The options are plans of actions that give a realistic and somewhat detailed course of action (which describes how the option will be implemented and who is involved in the implementation).*

*(It is not enough to give an option like "list prairie dogs as federally protected" because currently this option would be rejected by the government. So, your option should include how the option would be enacted or could be a step leading to the protection of prairie dogs. It is not enough to give an option like "control prairie dogs" because it is vague and begs the question of how you will control prairie dogs and in what situations.)*

**3. Criteria (4 points)** - Identify suitable criteria for comparing these alternative courses of action. Criteria are statements that say what you value in a potential solution to a problem. *To help you think about possible criteria, ask yourself: how are you going to choose between these options? What are the important things to consider?* Identify at least two criteria.

*0 – student does not describes criteria, or offers criteria that are unrelated to the issue.*  
*2—student describes only one criterion, or the connection to the issue is unclear or not compelling, or the criteria are not wide ranging (missing an important aspect of economics, environment, ethics, society or other).*  
*4— student describes criteria with clear and compelling connections to the issue and uses criteria that demonstrate a wide-ranging view of the issue (examining important aspects of economics, environment, ethics, society or other)*

*Hint: It might be helpful to think about a criteria statement starting with the following phrases:*

*Ensure that...*

*Minimize ....*

*Maintain the....*

*Increase.....*

**4. Information [11 points total]** – What additional information do you need to know about each option? Clarify the information known about possible alternatives, with particular reference to the criteria identified and to any scientific knowledge or evidence.

A) [3 points] What additional information do you need to help you analyze the potential outcome of each option? *The question should be something specific that you could research or look up, and something that you would include in an analysis of **your options** (step 5 below).* List at least 3 *specific* questions.

*0 – student does not offer questions that are important to the issue, or the question is not apparently related to the students' options or criteria.*

*1.5—student offers a questions that are important to analyzing their options based on their criteria, but the questions is so general and vague that it isn't clear how it is relevant to deciding the issue.*

*3—student offers detailed questions that are researchable and that are specific to evaluating their options based on their criteria.*

*\*\*\*Information that was not covered in class may be assigned a higher point value than information that was presented as part of the lecture or recitation material.*

Take one question that you wrote for A and look for that information. You may use the Internet, library resources, or email someone who might know. Then answer the following questions. If you are unable to find any information to satisfy your question, you may need to choose a different question and start again.

B) [1 point] What information did you look for?

C) [1 point] What information did you find?

D) [1 point] What was the source? (provide a link if applicable, write the complete reference, or explain who the person is and their expertise)

E) [1 point] How did you find it? (include both the *search engine* and what *search terms* you used)

F) [2 points] How will the information you found help you make a choice about the issue [specifically, how does the new information impact your decision, or sway your opinion towards a particular choice]?

*0 – The student doesn't explain how the information is connected to their options or criteria.*

*1 – The student doesn't have clear reasoning that links the information to their options or criteria.*

*2 – The student has clear reasoning and addresses specifically how the new information changes their decision in terms of their options or criteria*

G) [2 points] Do you think the information you found is trustworthy? Why or why not?

*0 – The student only says that it is or isn't trustworthy, but does not support it with clear reasoning.*

*1 – The student says that it is or isn't trustworthy, and supports it with some clear reasoning.*

*2 – The student says that it is or isn't trustworthy, and supports it with clear reasoning.*

*Hint: consider the article's relevance, accuracy, reliability and bias (perspective)*

### **Analysis of options based on the criteria (tradeoffs)**

**5A. (6 points)** - Evaluate each option against the criteria identified. Be sure to clearly describe how all of the all of the options you chose in Step 2 meet (or don't meet) all of the criteria you chose in Step 3 (above). You may use the example table as a way to organize your response (optional). In each square of the table: a) discuss how the specific option meets or does not meet the specific criteria, b) assign the criteria with an overall "score" for how well the criteria has been met using a scale from 1 (does not meet criteria) to 5 (meets criteria very well. See the first square for an example.

**5B. (2 points)** You must include the information found in Step 4 (above) in your analysis of advantages and disadvantages. Use an asterisk (\*) to indicate where the information was used in the table. (The information may only be relevant to one square in your table.)

Please be sure to fill in the row and column headers with a short phrase that indicates which option and criteria you are evaluating. Feel free to add more rows or columns to fit the number of options or criteria you have.

	Option #1-- _____	Option #2-- _____	Option #3-- _____
Criteria #1-- _____	<b>“Overall score = 3</b> <i>This option meets the criteria because....</i> <i>This option does not meet the criteria because....”</i>		
Criteria #2-- _____			
Criteria #3-- _____			

A.

0—student does not discuss all of the options they have laid out in #2 or the criteria they have laid out in #3, or the discussion of how well the option meets the criteria use just the overall scoring number or are extremely thin or unrealistic.

3—student discusses all of their options against each criteria, but is missing discussion of significant tradeoffs in terms of at least one option or is not very detailed or vague in the reasons why an option meets the criteria.

6—student thoroughly discusses each option including how well it does and does not meet each criteria. The discussion includes specific reasons why the criteria is or isn't met, and may mention areas where the student is uncertain whether the option meets the criteria and explains why. The overall scoring selected makes sense with the students' analysis of how well the option meets the criteria.

B.

0—student does not include the information they found in the analysis of advantages and disadvantages.

1—student includes the information they found, but it is not used in a way that connects or makes sense to the argument.

2—student includes the information they found, and it helps to clarify if the option will meet a criteria.

**6. Choice (1 points) – A)** Choose an “option” based on the analysis undertaken.

B) Why do you think this is the best option?

0—the student does not provide reasoning for their choice, or the reasoning is weak,

*unclear and disconnected with the criteria and tradeoffs discussed above*

*.5—the student provides reasoning for their choice that has some weak or unclear connections with the criteria and tradeoffs discussed above*

*1—the student provides clear and comprehensive reasoning for their choice that clearly links the choice with the criteria and tradeoffs discussed above*

**7. Review (4 points total)** – Reflect on your own decision-making process using these steps.

A) [2 points] What do you think of the decision you have made? How could you improve the way you made the decision?

*0—the student offers no reflection or what is offered demonstrates no thoughtfulness*

*1—the student offers some reflection of how the decision-making could be improved.*

*2—the student offers reflection that demonstrates thoughtfulness, including specific examples of how they could improve their decision.*

B) [2 points] Do you think your decision is viable? Why or why not?

*0—the student offers no reflection or what is offered demonstrates no thoughtfulness*

*1—the student offers some reflection that demonstrates some understanding of the issue, but maintains that an option is viable without careful examination.*

*2—the student offers reflection that demonstrates a deep enough understanding of the issue to understand what is a viable option, or is thoughtful about what they don't yet understand to determine what is viable.*

8. (2 points) Is there anything you could do to impact this issue? What are some things you could do and how might they impact the issue?

*0 – No answer.*

*1 – the action presented by the student are not clearly related to the issue.*

*2 – the action presented by the student is clearly related to the issue.*

9. (1 point) How important do you think this issue is to you personally? Rank the issue on a scale of 1 (not at all important) to 10 (one of the most important issues). \_\_\_\_\_

Why?

*1- complete answer to the question "why" and a rank given*

10. (1 point) How important do you think this issue should be to society? Rank the issue on a scale of 1 (not at all important) to 10 (one of the most important issues). \_\_\_\_\_

Why?

*1- complete answer to the question "why" and a rank given*



### **Appendix D**

#### **Student Interview Protocol**

Thanks for talking with me today. I just want to ask you some questions about the past couple lessons where you've thought about whether to build the wind farm. Please feel free to look at your completed worksheets as we talk. Remember, there's no right answer and this isn't a test. We just want to learn more about how you thought about this issue of whether or not to build the wind farm.

1. When I say wind farm, what comes to mind first?
2. What did you think was the problem at the beginning of the unit?
3. How did you decide what to define the problem as at the beginning of the unit?  
(Did other students mention certain things, was it based on what the teacher said, the articles you read, etc.)
4. Now that you're done with the unit, how would you define the problem?
5. Why is your problem statement different (or the same) from before?
6. Some people might say you should only care about the wind turbine farms if you live near them. Do you agree or disagree with this? Why?
7. Do you think the wind farm is an issue now? Will it be an issue in the future?
8. Do you think you belong to any of the stakeholder groups? Explain.
  - Look at your stakeholder impacts chart worksheet. You were asked to weight your stakeholders from most to least important. Where did you place your group?
  - Did you make your choice based on what your stakeholder group would most like?
9. Do you think you will ever need to address an issue like the wind farm issue?
10. How real and relevant was this issue to you and your life?

### Appendix E

Dimension	Close	Distant
Spatial	Indicates this is happening very close to them or their community.	Is uncertain that this is happening near to them or they say they don't live in the area where this is happening.
Temporal	They indicate this is something that is happening right now and needs to be solved right now. Some may say this is an issue happening now, but not in the future.	Student says this is something happening in the future or that they won't have to address the issue until the future.
Social	Talks about how "we" need to solve these things. A group of individuals they clearly identify with is of highest importance in the issue. (If a student identifies they are a part of the stakeholder groups, but says "I guess" or that "my parents are part of the group, but I'm not", this doesn't count as being close socially.	Only reports on other individuals who need to solve the issue. Or the student cannot identify that they belong to a group of stakeholders or they are not convinced they are a part of a group of stakeholders.
Hypothetical	Indicates that there is an issue that needs solved. The student believes this is a compelling issue that must be solved (they show evidence of understanding that people really do have arguments over the building of the wind farm and that it's understandable that they fight)	Indicates that certain aspects are very unlikely to happen. They don't think this is something most people will have to address or that they'll have to address.

## Appendix F

What NOT to code:

1. Repeats of the same information (e.g. in the following, “Wind turbines are good and bad. They are bad because....” the term bad should only be coded once).
2. A student’s statement about their own beliefs on if the wind turbine should or should not be built.
3. In the pro/con list, anything without a verb doesn’t get coded UNLESS it’s an adjective in and of itself (including no emissions).

General rules:

1. If/then statements are generally adjectives (however many statements there are in the sentence).
2. An expression of what others think should or should not happen are 3 followed by any other use of verbs/adjectives.
3. Remember that for something to be a VERB, it must signify an ACTION. Watch carefully to see if students are saying that something is an adjective or if an action is happening.
4. ONGOING actions are DAVs and potentially IAVs when the situation warrants it.

### Appendix G

	Positive	Mixed/Neutral	Negative
Problem statement	More positive points articulated than negative. Overall more positive impression of students' written response.	An approximately even amount of positive/negative characteristics of wind turbines mentioned. Overall impression of students' written response is neither positive or negative.	More negative points articulated than positive. Overall more negative impression of students' written response.
Criteria	Wind turbines satisfy more criteria than not or they create problems than they solve	Wind turbines meet and fail to meet criteria in approximately even amounts (a difference of 1-2 statements for a student who fills the whole criteria chart)	More criteria are not satisfied by wind turbines than are satisfied by wind turbines or wind turbines mostly create problems
Stakeholders	More positive outcomes for unique stakeholders are listed than negative.	Relatively equal number of positive and negative influences are given. Overall impression of students' written response is neither positive or negative.	More negative outcomes for unique stakeholders are listed than positive.

1. Starting with the stakeholders and criteria, work through each as you “cancel out” positive and negative statements until you can determine if there are more positive statements or negative statements. If they articulate more positives, they are considered to have a positive perception for these two portions of their work. If they articulate more negative points, they are considered to have a negative perception for these two portions of their work.
2. Looking at the problem statement, “cancel out” the positive and negative points articulated by the student until you can determine if there are more positive statements or negative statements. If they articulate more positives, they are considered to have a positive perception for these two portions of their work. If they articulate more negative points, they are considered to have a negative perception for these two portions of their work.

3. If there is a mismatch of perceptions, weigh the problem statement perception with twice the weight as the stakeholder and criteria perception by considering the number of extra positive or negative “points” in each portion. If there’s ultimately very little difference in how positive or negative their overall work was (less than 1-2 “points” of difference after weighting), they get a mixed/neutral designation. Otherwise, label them with the appropriate label.